BRITISH SURGICAL PRACTICE

AFRICA:	BUTTERWORTH & CO. (AFRICA), LTD. DURBAN: 1 LINCOLN'S COURT, MASONIC GROVE
AUSTRALIA:	BUTTERWORTH & CO. (AUSTRALIA), LTD. SYDNEY: 8 O'CONNELL STREET MELBOURNE: 430 BOURKE STREET BRISBANE: 240 QUEEN STREET
CANADA:	BUTTERWORTH & CO. (CANADA), LTD. TORONTO: 1367 DANFORTH AVENUE
NEW ZEALAND:	BUTTERWORTH & CO. (AUSTRALIA), LTD. WELLINGTON: 49/51 BALLANCE STREET AUCKLAND: 35 HIGH STREET

BRITISH SURGICAL PRACTICE

Under the General Editorship of

SIR ERNEST ROCK CARLING, F.R.C.S., F.R.C.P.
CONSULTING SURGEON, WESTMINSTER HOSPITAL

and

J. PATERSON ROSS, M.S., F.R.C.S.
SURGEON AND DIRECTOR OF SURGICAL CLINICAL UNIT, ST. BARTHOLOMEW'S HOSPITAL; PROFESSOR OF SURGERY, UNIVERSITY OF LONDON

IN EIGHT VOLUMES
(With Index Volume)

VOLUME 4

LONDON
BUTTERWORTH & CO. (PUBLISHERS), LTD.
BELL YARD, TEMPLE BAR
1948

MADE AND PRINTED IN GREAT BRITAIN BY
HAZELL, WATSON AND VINEY, LTD., AYLESBURY AND LONDON

Associate Editors for Special Subjects

CONTRIBUTORS

TO THIS VOLUME

FACIAL PALSY	JOSEPHINE COLLIER, F.R.C.S., Surgeon, Ear, Nose and Throat Department, Royal Free Hospital; Surgeon, Ear, Nose and Throat Department, South London Hospital for Women
FACIO-MAXILLARY INJURIES AND DEFORMITIES	RAINSFORD MOWLEM, F.R.C.S., Plastic Surgeon, Middlesex Hospital; Surgeon-in-Charge, Plastic Unit, Hill End Hospital (E.M.S.), St. Albans and B. W. FICKLING, F.R.C.S., F.D.S.Eng., Dental Surgeon, Royal Dental Hospital of London; Dental Surgeon, St. George's Hospital; Dental Surgeon, Maxillo-Facial Unit, Hill End Hospital (E.M.S.), St. Albans
FALLOPIAN TUBES	W. C. W. NIXON, M.D., F.R.C.S., F.R.C.O.G., Professor of Obstetrics and Gynaecology, University of London; Director, Obstetrical Unit, University College Hospital, London

FASCIAL GRAFTS

W. EDWARD GALLIE, M.D., F.R.C.S., F.R.C.S.(C)., F.A.C.S., Professor of Surgery and Head of Department, University of Toronto, Canada

FAT NECROSIS

GEOFFREY HADFIELD, M.D., F.R.C.P., Sir William H. Collins Professor of Human and Comparative Pathology, Royal College of Surgeons of England; Formerly Professor of Pathology, University of London; Formerly Pathologist, St. Bartholomew's Hospital, London

FIBROSITIS

W. S. C. COPEMAN, O.B.E., M.D., F.R.C.P., Physician-in-Charge, Rheumatism Department, West London Hospital; Medical Secretary, Empire Rheumatism Council
and
O. SAVAGE, O.B.E., M.R.C.P., Chief Assistant, Rheumatism Department, West London Hospital; Deputy Medical Secretary, Empire Rheumatism Council

FILARIASIS

W. L. HARNETT, C.I.E., M.D., F.R.C.S., Lieutenant-Colonel, Indian Medical Service (Retired); Formerly Professor of Surgery, Medical College, Calcutta

FISTULA IN ANO	E. T. C. MILLIGAN, O.B.E., M.D., F.R.C.S., F.R.A.C.S., Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon, London and C. NAUNTON MORGAN, F.R.C.S., Surgeon, St. Bartholomew's Hospital; Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon; Surgeon, Hospital for Tropical Diseases, London and O. V. LLOYD-DAVIES, M.S., F.R.C.S., Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon, London and HENRY R. THOMPSON, F.R.C.S., Assistant Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon, London
FOCAL EPILEPSY	WILDER PENFIELD, C.M.G., D.Sc., M.D., F.R.C.S., F.R.S.. Professor of Neurology and Neurosurgery, McGill University; Director, Montreal Neurological Institute; Surgeon, Royal Victoria and Montreal General Hospitals
FOOT—SURGERY OF	T. T. STAMM, F.R.C.S., Orthopaedic Surgeon, Guy's Hospital, London
FRACTURES, DISLOCATIONS, FRACTURE-DISLOCATIONS AND ALLIED INJURIES	F. W. HOLDSWORTH, M.Chir., F.R.C.S., Orthopaedic Surgeon, Sheffield Royal Infirmary and *Sheffield Children's Hospital*; Lecturer in Orthopaedic Surgery, University of Sheffield.

FROST-BITE	NORMAN C. LAKE, D.Sc., M.D., M.S., F.R.C.S., Senior Surgeon and Director, Surgical Division, Charing Cross Hospital; Senior Surgeon, Bolingbroke Hospital, London
GALL-BLADDER AND BILE PASSAGES	J. B. OLDHAM, V.R.D., F.R.C.S., Surgeon, Royal Liverpool United Hospital; Lecturer in Surgery, University of Liverpool
GANGLION	R. M. HANDFIELD-JONES, *M.C.*, M.S., F.R.C.S., Surgeon, St. Mary's Hospital, London
GANGRENE, CLOSTRIDIAL (GAS GANGRENE)	F. A. R. STAMMERS, C.B.E., Ch.M., F.R.C.S., Professor of Surgery, University of Birmingham; Surgeon, Birmingham United Hospital
GASTRO-COLIC FISTULA	SIR HENEAGE OGILVIE, K.B.E., M.D., M.Ch., F.R.C.S., F.R.C.S.(C.), Hon.F.R.A.C.S., Hon.F.A.C.S., Hon.M.S.Fouad I, Surgeon, Guy's Hospital; Surgeon, Royal Masonic Hospital, London
GASTROSTOMY	A. J. C. LATCHMORE, M.B.E., M.S., F.R.C.S., Assistant Surgeon, General Infirmary, Leeds; Surgeon, Clayton Hospital, Wakefield
GENITAL ORGANS—FEMALE EXTERNAL	J. ERIC STACEY, M.D., F.R.C.S.Ed., F.R.C.O.G., Surgeon, Jessop Hospital for Women, Sheffield; Senior Lecturer in Obstetrics and Gynaecology, University of Sheffield

GLAND-PUNCTURE AND ASPIRATION BIOPSY	L. C. D. HERMITTE, M.B., Ch.B., D.T.M. & H., Pathologist, Royal Infirmary, Sheffield; Lecturer in Pathology, University of Sheffield and FRANK ELLIS, M.Sc., M.D., F.F.R., Director, Radiotherapy Department, London Hospital
GLANDERS	G. H. WOOLDRIDGE, F.R.C.V.S., M.R.I.A., Emeritus Professor of Veterinary Medicine, Royal Veterinary College, London and Sir ERNEST ROCK CARLING, F.R.C.S., F.R.C.P., Consulting Surgeon, Westminster Hospital
GLAUCOMA	R. AFFLECK GREEVES, F.R.C.S., Consulting Surgeon, Moorfields, Westminster and Central Eye Hospital; Consulting Ophthalmic Surgeon, Middlesex Hospital, London
GLOMUS TUMOURS	W. A. MACKEY, F.R.F.P.S., F.R.C.S.Ed., Assistant to the Professor of Surgery, University of Glasgow; Visiting and Consulting Surgeon, Corporation of Glasgow
GLOTTIS—OEDEMA OF	I. G. ROBIN, F.R.C.S., Surgeon (Ear, Nose and Throat), Royal Northern Hospital; Laryngologist, Royal Chest Hospital; Assistant Surgeon, Ear, Nose and Throat Department, St. Mary's Hospital, London

GONORRHOEA	R. C. L. BATCHELOR, D.P.H., F.R.C.S.Ed., Clinical Officer, Edinburgh Corporation Venereal Disease Scheme; Surgeon-in-Charge of Venereal Diseases, Edinburgh Royal Infirmary
GOUT	GEORGE GRAHAM, M.D., F.R.C.P., Consulting Physician, St. Bartholomew's Hospital, London
GUNSHOT WOUNDS AND ALLIED INJURIES (GENERAL MANAGEMENT)	C. G. ROB, *M.C.*, M.Chir., F.R.C.S., Surgeon-in-Charge, Out-patients Department, St. Thomas's Hospital, London
HAEMATOMA	A. WALLIS KENDALL, M.S., F.R.C.S., Surgeon, King's College Hospital; Surgeon, Queen Elizabeth Hospital for Children, London
HAEMOPHILIA AND OTHER HAEMORRHAGIC STATES	R. G. MACFARLANE, M.D., Radcliffe Lecturer in Haematology, Oxford University; Clinical Pathologist, Radcliffe Infirmary, Oxford
HAEMORRHAGE	R. H. BOGGON, M.S., F.R.C.S., Surgeon, St. Thomas's Hospital, London
HAND	J. N. BARRON, F.R.C.S.Ed., Senior Surgeon, Plastic and Jaw Unit, Park Prewett Hospital, Basingstoke
HEART AND PERICARDIUM	OSWALD S. TUBBS, F.R.C.S., Thoracic Surgeon, St. Bartholomew's Hospital; Assistant Surgeon, Hospital for Consumption and Diseases of the Chest, London

HERNIA	JULIAN TAYLOR, O.B.E., M.S., F.R.C.S., Surgeon, University College Hospital; Surgeon, National Hospital, London
HERNIA—DIAPHRAGMATIC	Sir THOMAS P. DUNHILL, K.C.V.O., C.M.G., M.D., F.R.C.S., F.R.A.C.S., Consulting Surgeon, St. Bartholomew's Hospital, London
HERPES ZOSTER	E. A. CARMICHAEL, C.B.E., F.R.C.P., Physician, Out-Patient Department, National Hospital, London; Director of Neurological Research Unit, Medical Research Council
HETEROTOPIA	A. L. TAYLOR, M.D., Pathologist, Bristol Royal Hospital; Lecturer in Clinical Pathology, University of Bristol
HICCUP	E. R. BOLAND, M.D., F.R.C.P., Physician, Guy's Hospital, London

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF PLATES

/

FACIAL PALSY

By JOSEPHINE COLLIER, F.R.C.S.
SURGEON, EAR, NOSE AND THROAT DEPARTMENT, ROYAL FREE HOSPITAL;
SURGEON, EAR, NOSE AND THROAT DEPARTMENT, SOUTH LONDON HOSPITAL FOR WOMEN

1. DEFINITION

147.] Paralysis of the facial muscles apart from other neurological lesions may be due to injury or disease of the ear or may occur as an isolated condition. The term Bell's palsy should be restricted to the second group of cases.

2. AETIOLOGY

The facial nerve may be damaged during mastoid operations, though with modern surgical technique this should be a rare accident. It may be injured by gunshot wounds and penetration of bomb fragments of the mastoid process and middle ear. It is also exposed to injury from the indirect violence of fracture of the base of the skull. Occasionally the pressure of obstetric forceps damages the facial nerve after its exit from the stylomastoid foramen. *Trauma*

The terminal branches and groups of branches may be injured by fragments of flying glass and similar missiles. Operations for parotid abscesses and neoplasms and for removal of glands in the upper cervical region may cause damage to branches of the facial nerve unless the incision is planned to avoid them. *Injuries to branches*

Suppuration of middle ear and mastoid

Facial paralysis may occur in the course of acute or chronic suppurative otitis media. It is a rare complication in acute otitis media (0·5 per cent), but is found three times as often with chronic suppuration because of the effects of secondary cholesteatoma, which may erode the bony wall of the Fallopian canal. Tuberculous infection of the mastoid in infants and young children sometimes causes necrosis of the canal.

Neoplasms

Facial paralysis is an early sign in malignant disease of the middle ear and external auditory canal, and in the rare condition of intratemporal epidermoid (primary cholesteatoma). It is found also with neoplasms of the parotid gland.

The common form of facial palsy occurring as an isolated symptom in an otherwise healthy individual is due either to neuritis of unknown origin or to herpes of the geniculate ganglion produced by a virus infection (Ramsay Hunt syndrome).

3. SURGICAL ANATOMY AND PATHOLOGY

(1) Anatomy in temporal bone

Course of nerve

The facial nerve enters the petrous temporal bone at the internal auditory meatus and passes outwards to the inner wall of the middle ear, where the geniculate ganglion is situated. Here the facial nerve, carrying also the sensory fibres of the chorda tympani, turns directly backwards and traverses the inner wall of the middle ear, forming a ridge covered by a thin plate of bone, or occasionally covered only by mucous membrane. After passing above the foramen ovale the nerve turns downwards in the inner wall of the aditus below the smooth, dense, bony prominence of the external semicircular canal. Here the nerve and the external semicircular canal lie deep to the postero-superior wall of the bony external auditory meatus. From the aditus the nerve passes vertically downwards, deep to the posterior meatal wall, to emerge under cover of the mastoid tip and the posterior belly of the digastric muscle at the stylomastoid foramen, whence it crosses the styloid process and enters the parotid gland. The chorda tympani enters the Fallopian canal to join the facial nerve about 6 millimetres above the stylomastoid foramen.

Fallopian canal



Fig. 1.—Dissection of left temporal bone showing cells opening into Fallopian canal.

From the external semicircular canal to the stylomastoid foramen the nerve completely fills the bony canal in which it lies, and to the periosteum of which its sheath is firmly attached. This peculiarity is responsible for its vulnerability both to surgical hazard and to pathological processes, which in other nerves produces only transitory and negligible results. Vascular changes—response to the stimulus of inflammation or of trauma—immediately lead to pressure on the nerve, which if sufficient or long maintained leads to degeneration of the nerve fibre. On the opposite side of the account, the presence of the firm Fallopian canal facilitates end-to-end apposition of a nerve graft, obviates the necessity for suture of such a graft and thus minimizes the formation of scar tissue, and so favours regeneration (Fig. 1).

(2) Operative injuries

(a) Infant mastoid

Before the mastoid process is fully developed, between the second and third years of life the stylomastoid foramen is exposed on the lateral aspect of the skull, and the facial nerve is uncovered as it emerges. In this situation it may easily be cut when making the skin incision for mastoiditis in young children if its subcutaneous position is not borne in mind (Fig. 2). The relatively large mastoid antrum is situated above, and posterior to, the middle ear in these patients, and the skin incision should be planned accordingly (Fig. 3).

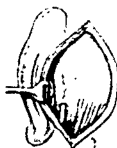


Fig. 2.—Left ear of infant showing exit of facial nerve on lateral aspect.



Fig. 3.—Left ear of infant showing exposure of antrum postero-superior to external meatus.

(b) Cortical mastoid (Schwartze)

Sometimes a forward-placed lateral sinus associated with a low middle fossa encroaches on the mastoid antrum, leaving a restricted area for surgical approach (Fig. 4). In such cases the surgeon is tempted to cut down the *Forward lateral sinus*



Fig. 4.—Dissection of left mastoid showing forward lateral sinus and low middle fossa encroaching on antrum.



Fig. 5.—Dissection of left mastoid showing danger of injury to facial nerve if the posterior meatal wall is removed in a cortical mastoid operation.



Fig. 6.—Dissection of left mastoid showing danger of removing the lower part of the posterior meatal wall in a radical mastoid operation.

posterior bony wall to facilitate opening the antrum. When this is done there is increased risk of damage to the facial nerve. The integrity of the posterior bony meatal wall should always be preserved in cortical operations (Fig. 5).

Too low approach to the antrum is another error that may lead to an opening being made into the facial canal. The facial nerve is also exposed to injury when clearing the mastoid cells behind the posterior meatal wall. These *Too low approach to antrum*

sometimes actually *open into the facial canal and should not be explored* by a bent probe, but opened under direct vision.

(*c*) *Radical mastoid*

Removal of bridge

In the radical mastoid operation the facial nerve is exposed to injury during the removal of the "bridge" *of the postero-superior wall of the bony meatus,* deep to which lies the external semicircular canal, and below this is the bend of the facial nerve. Removing too much of the lower part of the posterior meatal wall may expose the facial nerve and lead to injury if this is not recognized (Fig. 6). Damage may also be done in removing granulations from the inner wall of the middle ear. A good light, careful haemostasis with hot saline solution and suction, or an adrenaline pack, should prevent these accidents. Unavoidable tearing of the nerve in its petrous segment may occur from separation or removal of a sequestrum of the labyrinth.

Middle-ear damage

Sequestrum

Tight packing of the radical mastoid cavity is occasionally responsible for a facial palsy developing at an interval after operation, an exposed nerve being compressed by the pack. This is likely to clear up rapidly on release of the pressure.

(3) Operative findings

Exploration of the mastoid wound in cases of post-operative facial palsy may reveal compression or transfixion by a detached fragment of bone, haemorrhage or oedema within an intact sheath, a torn sheath or section of the nerve with loss of nerve substance, and later, the cut ends involved in fibrous tissue. Simple section with the ends in apposition is seldom if ever found (Collier, 1940). If there is loss of nerve substance in the middle ear after a supposed cortical operation the integrity of the middle ear will have been destroyed by the operation.

(4) Fracture of the skull

Closed head injuries

Facial palsy in fractures of the base of the skull is due to injury in the middle ear, or more rarely, in the internal auditory meatus. The paralysis may be immediate or delayed. When immediate it is due to laceration (a lesion in *continuity) or to bruising (transient block). Delayed onset* is probably caused by haemorrhage into the Fallopian canal. Deafness when present may be of middle ear or internal ear type, and the presence of one or the other will help to indicate the site of the nerve injury. Fractures of the petrous bone cannot always be demonstrated by an x-ray examination.

Deafness

X-ray

Gunshot wounds and penetration by bomb fragments of the mastoid process and its neighbourhood may injure the facial nerve in the bone, or after its exit from the stylomastoid foramen. These injuries are frequently associated with fracture of the neck of the mandible and the bony external auditory meatus and with lacerations of the cartilaginous external canal. The swelling and desquamation of the canal are followed by the formation of persistent granulations, which may block the canal and later lead to stenosis.

(5) Acute middle-ear suppuration

The facial palsy that occasionally occurs with acute suppurative otitis media without mastoiditis is due to vascular congestion and oedema. *When* mastoiditis develops, periostitis of the canal, or the pressure *of pus in a cell* communicating with the canal, may be responsible.

(6) Chronic middle-ear suppuration

When facial palsy occurs during the course of chronic suppurative otitis media, an acute exacerbation with oedematous granulation tissue compressing an exposed nerve or the erosion of a cholesteatoma is generally responsible. A fistula may be found at operation, generally at the bend of the nerve in the aditus, but not every fistula in the canal is associated with facial palsy. The cholesteatoma may also have eroded the external semicircular canal, so the state of the labyrinth should be investigated by the fistula and the caloric tests.

(7) Bell's palsy

Acute neuritis

Traditionally, Bell's palsy is believed to be the result of an acute inflammation of the sheath of the facial nerve brought on by exposure to cold. More than one pathological process may be responsible, but, whatever the cause, conduction of the nerve impulse is prevented temporarily or permanently because the nerve is compressed by vascular swelling or exudate, confined as it is in a narrow bony canal. A proportion of cases are associated with herpetic lesions on the auricle, external auditory canal and the tympanic membrane, the sensory area of the seventh nerve connected with the geniculate ganglion. Pressure of the swollen ganglion or a distal, and possibly a proximal, extension of the inflammation to the sheath and connective tissue of the nerve is thought to compress the axons. In mild cases of Bell's palsy which recover rapidly conduction is blocked temporarily, but if the ischaemic block is prolonged, the axons undergo Wallerian degeneration which must be completed before regeneration can occur. Lumbar puncture sometimes shows a lymphocytosis of the cerebrospinal fluid.

Herpes

Cerebro-spinal fluid

Recent post-mortem investigations suggest that herpes zoster, including the otitic variety, may depend in part upon a poliomyelitis and a neuritis as well as a ganglion lesion, thus explaining the coincidence of pain, motor palsy and the presence of lymphocytes in the cerebrospinal fluid (Denny-Brown, Adams and Fitzgerald, 1944). It is possible that Bell's palsy is always the result of this syndrome. The occurrence of cases of spontaneous facial palsy in small groups suggests a virus infection.

Operative findings on decompression

On decompressing the nerve for Bell's palsy in the presence of a negative faradic response I have sometimes found a normal nerve, at other times an attenuated nerve compressed by fibrous tissue at the stylomastoid foramen or with dense scar extending over varied lengths of the vertical course. The success or failure of the operation has had little relation to the operative findings or the treatment, suggesting that in the cases in which there was no return of movement the lesion was central to the middle ear. Morris (1938) found the nerve oedematous when the faradic response was present, and in later cases, from 6 months to 2 years after onset, a nerve that appeared too large for the canal.

4. DIAGNOSIS

Infranuclear lesions

Patients with facial palsy should have a complete examination of the central nervous system. Peripheral palsies have the features of a lesion of the lower motor neurone. They are distinguished from supranuclear lesions by the absence of emotional as well as voluntary movements, and by the fact that

sometimes actually open into the facial canal and should not be explored by a bent probe, but opened under direct vision.

(*c*) *Radical mastoid*

In the radical mastoid operation the facial nerve is exposed to injury during the removal of the "bridge" of the postero-superior wall of the bony meatus, deep to which lies the external semicircular canal, and below this is the bend of the facial nerve. Removing too much of the lower part of the posterior meatal wall may expose the facial nerve and lead to injury if this is not recognized (Fig. 6). Damage may also be done in removing granulations from the inner wall of the middle ear. A good light, careful haemostasis with hot saline solution and suction, or an adrenaline pack, should prevent these accidents. Unavoidable tearing of the nerve in its petrous segment may occur from separation or removal of a sequestrum of the labyrinth.

Removal of bridge

Middle-ear damage

Sequestrum

Tight packing of the radical mastoid cavity is occasionally responsible for a facial palsy developing at an interval after operation, an exposed nerve being compressed by the pack. This is likely to clear up rapidly on release of the pressure.

(3) Operative findings

Exploration of the mastoid wound in cases of post-operative facial palsy may reveal compression or transfixion by a detached fragment of bone, haemorrhage or oedema within an intact sheath, a torn sheath or section of the nerve with loss of nerve substance, and later, the cut ends involved in fibrous tissue. Simple section with the ends in apposition is seldom if ever found (Collier, 1940). If there is loss of nerve substance in the middle ear after a supposed cortical operation the integrity of the middle ear will have been destroyed by the operation.

(4) Fracture of the skull

Facial palsy in fractures of the base of the skull is due to injury in the middle ear, or more rarely, in the internal auditory meatus. The paralysis may be immediate or delayed. When immediate it is due to laceration (a lesion in continuity) or to bruising (transient block). Delayed onset is probably caused by haemorrhage into the Fallopian canal. Deafness when present may be of middle ear or internal ear type, and the presence of one or the other will help to indicate the site of the nerve injury. Fractures of the petrous bone cannot always be demonstrated by an x-ray examination.

Closed head injuries

Deafness

X-ray

Gunshot wounds and penetration by bomb fragments of the mastoid process and its neighbourhood may injure the facial nerve in the bone, or after its exit from the stylomastoid foramen. These injuries are frequently associated with fracture of the neck of the mandible and the bony external auditory meatus and with lacerations of the cartilaginous external canal. The swelling and desquamation of the canal are followed by the formation of persistent granulations, which may block the canal and later lead to stenosis.

(5) Acute middle-ear suppuration

The facial palsy that occasionally occurs with acute suppurative otitis media without mastoiditis is due to vascular congestion and oedema. When mastoiditis develops, periostitis of the canal, or the pressure of pus in a cell communicating with the canal, may be responsible.

be detected only by exploration, but whatever the degree of damage, degeneration of the axons and prolonged denervation with its attendant complications are inevitable. Operation on the nerve should therefore be undertaken as soon as the general condition of the patient permits. If evidence of labyrinthine irritation—vertigo, vomiting and spontaneous nystagmus—is also present, indicating a coincident injury to the external semicircular canal, it will be necessary to wait until this subsides.

Delayed paralysis

Onset of facial palsy some days after a mastoid operation will not be due to section of the nerve, and it is justifiable to wait until the electrical reactions can be carried out; if after fourteen days the faradic response is negative, electromyography should also be done. Packing in the mastoid cavity should, however, be removed at once when the facial palsy is observed.

Late cases

If the patient is seen at an interval after the operation, the history of onset of the facial palsy—immediate or delayed, a history of vertigo immediately after the operation, the present condition of the labyrinth (that is, the presence of a "dead" labyrinth as shown by the caloric tests), and the results of electrical testing and electromyography, will provide the indications for operation. Loss of faradic response, the absence of motor unit action potentials and the presence of fibrillation action potentials (as shown by electromyography) are evidence of complete denervation. Exploration in such cases always shows serious damage to the nerve. But if by electromyography a mixture of fibrillation and nascent motor unit action potentials is shown, even though the faradic response is negative, re-innervation of the muscles is occurring and spontaneous recovery can be anticipated. Absence of the galvanic response indicates fibrous atrophy which is irreversible. If this is found in the muscles around the eye and mouth any operation on the nerve is contra-indicated. Lack of galvanic response in the frontalis muscle is less important. In any case movement seldom if ever returns to this muscle when it has been denervated for a long time.

Evidence of old labyrinthine injury

Signs of re-innervation

Mastoid wounds treated conservatively

Facial palsy due to gunshot wounds of the mastoid should not be explored in the first instance. The wound should be treated conservatively; the mastoid antrum need not be opened. If the facial palsy persists after the wound is healed the indication for operation should be considered as for post-operative and closed head injuries.

Site of injury in fractured base

Facial palsy from closed head injuries clears up rapidly in the majority of patients. If it is delayed the recovery is likely to be imperfect, but the difficulty of deciding whether the nerve has been injured before it reaches the middle ear and is thus inaccessible makes the indication for operation indefinite. The condition of the middle ear and labyrinth, the presence of middle or internal ear deafness, may help to determine the site of injury.

Acute middle-ear suppuration

Chronic middle-ear suppuration

The treatment of facial palsy in the course of acute suppurative otitis media and acute mastoiditis is that of the ear condition. In the large majority of cases the palsy clears up with the resolution of the inflammation. In chronic suppurative otitis media the radical operation should be done; great care is necessary in removing granulations and cholesteatoma, as the nerve may be unrecognizable. In such cases the nerve should be decompressed from the stylomastoid foramen up to the affected portion, but its sheath should not be incised. Grafting may be necessary later if movement does not return and electromyography indicates complete denervation.

Onset

there is loss of movement in the whole face. The onset is likely to be sudden in Bell's palsy. It may be sudden or take a day or two to develop in suppurative lesions of the mastoid and middle ear, whereas with infratemporal epidermoids the palsy may progress slowly over several months before it becomes complete (Jefferson and Smalley, 1938).

The appearance of facial palsy immediately after an operation on the mastoid process indicates complete division of the nerve, whereas its appearance after a few days may be due to haemorrhage or to pressure from detached bone or tight packing. Facial palsy should be looked for specifically when injury to the nerve has been suspected, as its occurrence during the post-anaesthetic period in a bandaged patient may be missed until the following day.

Unconscious patients

Similarly, in unconscious patients with closed head injuries there may be difficulty in determining the time of onset, which is important from the point of view of prognosis, immediate palsy tending to recover slowly and incompletely.

5. AIDS TO DIAGNOSIS AND PROGNOSIS

(1) Electrical reactions

The electrical reactions should be tested about 14 days after the onset of paralysis. Earlier than this a faradic response may still be obtained even though the nerve has been completely divided. If a faradic response is present the paralysis is due to interference with conduction, and not to organic damage (reversible ischaemic block), and recovery is likely to be rapid and complete. Loss of faradic response shows interruption of axons but gives no indication as to the possibility of regeneration. Sometimes voluntary movements return before the faradic response. When muscles have been denervated for prolonged periods fibrosis occurs, and the muscles fail to respond to galvanism.

Under anaesthetic

If the patient will not tolerate sufficient faradic current it may be necessary to test under an anaesthetic.

(2) Electromyography

Electromyography is useful in cases of facial palsy in which the faradic response is absent and the question of operation on the facial nerve is being considered. Normal innervation in a paralysed muscle, partial or complete denervation, and minimal re-innervation before return of function, can all be shown by examining the spontaneous electrical activity of the muscles by means of electromyography (Weddell, Feinstein and Pattle, 1944). Repeated examinations after an interval may be necessary before a definite prognosis can be given.

(3) Taste

Loss of taste in the anterior two-thirds of the tongue indicates a lesion proximal to the entrance of the chorda tympani—about 6 millimetres above the stylomastoid foramen. Presence or absence of taste has little significance for prognosis.

6. INDICATIONS FOR SURGICAL INTERVENTION

Immediate post-mastoidectomy paralysis

If facial palsy is present immediately after an operation on the mastoid, a severe injury must have been inflicted on the nerve. The nature of the injury—compression by detached bone, or section with loss of nerve substance—can

8. OPERATIVE TECHNIQUE

Operations on the facial nerve are difficult and tedious, and should be undertaken only by those experienced in mastoid surgery, and after careful practice on the cadaver. *Exploration* The first stage is one of exploration. The nerve should be exposed from the stylomastoid foramen upwards. Care must be taken in detaching the posterior belly of the digastric from its groove, to avoid damaging the nerve at its exit. Exposure of the vertical descending portion of the nerve may be all that is necessary. In such cases the middle ear is not touched. If the facial nerve is involved in its horizontal course by suppuration or trauma the middle ear is already damaged. Further destruction by the radical mastoid operation to expose the middle-ear segment will not materially increase the hearing defect. When the site of injury is located it is necessary to decide whether the nerve is completely or partially interrupted. *Nerve grafting* If there is complete severance and the central end is accessible, nerve grafting is done, after cutting away sharply the part involved in scar. In a partially divided nerve any uncut vestige of nerve should be spared and the graft placed alongside it. *Synkinesia* Retaining as much as possible of any part injured in continuity is likely to minimize the development of post-operative synkinesia. If the nerve is intact, pressure outside is relieved by removing the detached fragment of bone or scar tissue, whereas pressure within the sheath from oedema or haemorrhage is treated by incising the sheath with a Graefe knife. This decompression should also be done above and below the segment grafted. *Inaccessible central end* If the central end of the nerve is inaccessible grafting is impossible. When the nerve is divided outside the skull—in infants and from gunshot wounds—difficulty may be experienced in finding the lower end, but once found, grafting is facilitated by the use of fibrin suture, which holds the ends together and provides a firm support (Young and Medawar, 1940).

Obtaining graft The lateral cutaneous nerve of the thigh is the most convenient for facial nerve grafting. It pierces the deep fascia between sartorius and tensor fasciae latae, about 4 inches below the antero-superior iliac spine, where it is about the same calibre as the facial nerve. The graft and the peripheral end of the nerve should be handled gently, as successful regeneration depends upon active co-operation of the living Schwann cells. *Nerve cut with scissors* The graft should be cut with a razor blade, and the divided ends of the nerve in the bone with sharp iridectomy scissors. As grafts tend to shrink and shorten it is necessary to use one longer than the gap, and to ensure that it lies in the bed of the Fallopian canal, with its ends accurately opposed to those of the cut nerve. *Fibrin suture* As there is no tension on the facial nerve graft the fibrin suture can be made from ordinary blood plasma mixed with a little tissue extract at the operation; in this way, a firm jelly is formed which holds the graft between the ends of the nerve. No further protection is necessary. Even when the Fallopian canal has been destroyed and there is no channel to splint the graft the rigid gel of the plasma provides a firm support. Antiseptics and sulphonamide powders should be avoided as they interfere with regeneration. The mastoid wound is sutured except for a small drain at the lower end. *Preliminary degeneration* Preliminary degeneration of the graft is not necessary as it does not facilitate regeneration.

If a faradic response is obtained in any type of Bell's palsy later than 14 days from the onset, early and satisfactory recovery can be anticipated. This occurs in about 85 per cent of cases. Patients with a negative faradic response present a more difficult problem. Recovery is likely to be slow, and when it occurs may be incomplete and marred by synkinesia, contractures and spasms or isolated purposeless movements. Electromyography has particular value in assessing the possibility of spontaneous recovery in patients with a negative faradic response, and should always be done before an operation for decompressing the nerve is considered. Operation on the nerve is not justified in patients with any evidence of re-innervation. After excluding these, there remains the rare case which gives no sign of return of function. Owing to the difficulty of deciding with present knowledge whether such cases are due to inflammatory lesions proximal to the middle ear as suggested in the section on pathology, decompression of the nerve should only be advised after explaining the position to the patient.

Delayed recovery

Evidence of re-innervation

7. PRE-OPERATIVE TREATMENT

General treatment for facial palsy

Treatment of paralysed facial muscles should be carried out on the same plan from the onset of the paralysis, whether recovery is anticipated, or an operation is in view, or during the post-operative period. Failure to keep these thin and delicate muscles relaxed from an early stage is responsible for much subsequent disfigurement, both with spontaneous recovery and after operation. Stretching by the pull of the muscles on the sound side must be prevented. The customary hook in the angle of the mouth attached to the ear defeats its object by stretching the sphincter-like orbicularis oris.

Intra-oral splint

An intra-oral splint which supports the angle of the mouth and the elevators of the upper lip is better for keeping the muscles in a position of relaxation. Such an intra-oral support can easily be made of plastic by a dental surgeon to fit natural teeth or dentures. It should be quite inconspicuous, only the hook-shaped plastic fitment, moulded to the exact shape of the angle of the mouth and symmetrical with the opposite side being visible (Allen and Northfield, 1944). Elevation of the upper lip and angle of the mouth by strapping (with adhesive plaster, *not* Elastoplast) is a useful substitute while an intra-oral splint is being made. There are two distinct stages in recovery. In the early stage before regeneration of the nerve is completed, when there is no voluntary movement, exercises should not be attempted. Besides discouraging the patient, efforts at voluntary movement lead only to over-action of the sound side. Treatment should aim at maintaining the nutrition of the muscles and preventing atrophy by means of massage and galvanism. Opinion has been divided as to the value of galvanism, but recent experimental and clinical evidence in injuries of peripheral nerves in the limbs has demonstrated that atrophy and degeneration of muscle can be limited by regular galvanic stimulation from the onset of paralysis. When voluntary movement has begun galvanism should give way to re-education. The patient should be taught to practise before a mirror, being careful to make the unaffected muscles of the sound side move only as much as those which are recovering. He should learn to cultivate an impassive face in order that movement of the normal muscles more nearly matches the affected side (Collier, 1940).

Strapping

Physiotherapy

Re-education


(a)


(b)

FIG. 8.—(a) Girl aged 12. Complete right facial palsy. 18-millimetre nerve graft to replace 12-millimetre loss of nerve substance. (b) Three years after graft operation, emotional movements show weakness of elevators of upper lip and angle of mouth. Synkinesia shown as dimple in chin. (c) Three years after graft operation, face symmetrical in repose with eyes closed. (d) and (e) Ten years after graft operation, natural smile, weakness of elevators, minimal synkinesia.

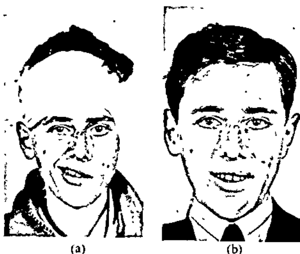

(c)


(d)

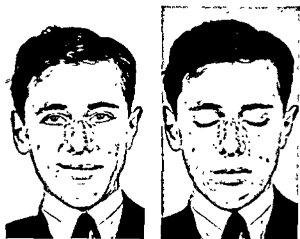

(e)

9. POST-OPERATIVE TREATMENT

Care of the facial muscles during the post-operative period should be carried out as indicated under *pre-operative treatment*. It is important that exercises should not be begun before the appearance of voluntary power. Daily treatment by massage and galvanism is necessary before any sign of re-innervation appears, particularly in the early stages. When movement returns the physiotherapist's instructions and encouragement are valuable, but the patient can carry out the daily treatment before a mirror at home.



(a) (b)



(c) (d)

FIG. 7.—(a) Boy aged 14. Complete left facial palsy after mastoid operation. 14-millimetre graft used to make good loss of about 10 millimetres. (b) and (c) Six months after graft operation, natural smile, equal palpebral fissures, weakness of elevators of mouth (d) Synkinesia shown by minimal contraction angle of mouth and dimple in chin on closing eyes.

10. RESULTS OF TREATMENT

Factors influencing results

Re-innervation of the facial nerve by operative repair of the nerve in the temporal bone restores emotional and voluntary movements, but the quality of the result *is affected by: (1) the* length of time the muscles have been denervated; (2) an *operative technique* that minimizes the formation of scar tissue around the nerve; and (3) the pre-operative and post-operative care of the muscles. Signs of recovery after nerve grafting cannot be expected before 6 months have elapsed, and may take 2 years. The face should be more or less symmetrical at rest, but on movement, particularly in the ordinary play of facial expression, a difference between the two sides will be noticed. This may be due to weakness from wasting of individual muscles or parts of muscles, to synkinesia or associated movements, or to isolated purposeless movements or spasms.

Asymmetry

Movement never returns to the frontalis if its denervation has been prolonged, probably because of early fibrosis. Good physiotherapy should limit

Contractures with deepening of the naso-labial fold may occur after incomplete division of the nerve and after partial recovery; they may mask muscle weakness. With the return of emotional movements the patient will lose self-consciousness and embarrassment, so that the psychological benefit may exceed the anatomical and aesthetic standard of the recovery (Figs. 7, 8 and 9). *Contractures* *Psychological results*

11. ROLE OF PLASTIC SURGERY

The deformity of facial palsy can be mitigated by using fascial strips to support the paralysed muscles and to counteract the pull of the sound side. This is more successful than the attempt to restore movement by utilizing the temporal and masseter muscles. These fascial strips can be used for temporary support in place of intra-oral or external splinting. A small plastic operation such as tarsorrhaphy is sometimes valuable as an ancillary after a nerve operation when movement has returned, but asymmetry persists. Plastic surgery is useful for cases in which the central end of a divided facial nerve is inaccessible, as in some fractures of the base of the skull, after removal of a sequestrum of the petrous bone, and in some cases of operative injury or after an operation for a tumour of the auditory nerve. The results are generally superior to anastomosis with another cranial nerve. *Fascial strips* *Temporary support*

Finally a plastic operation is the only available treatment for reducing facial disfigurement when the muscles are so wasted and fibrotic that the galvanic response is absent. Movement cannot be restored but the worst features of the deformity can be masked and the patient feels more comfortable and less self-conscious. *Fibrotic muscles*

12. ANASTOMOSIS OPERATIONS

When the central end of a divided facial nerve is not accessible for nerve grafting, improvement in appearance can be effected by anastomosis with another cranial nerve or by plastic surgery. Nerve anastomosis can restore tone to the facial muscles and provide symmetry at rest. Some degree of voluntary movement may be obtained but the emotional movements of facial expression are seldom if ever restored. The associated movements produced on voluntary movement vary; sometimes they are distressing and unsightly—a shrugging of the shoulder if the spinal accessory is used, or grimaces when swallowing if the hypoglossal is employed. These movements are said to diminish with time and are minimal when recovery of voluntary facial movements is limited. Loss of the accessory supply to the sternomastoid and trapezius leads to drooping of the shoulder; the atrophy of the corresponding half of the tongue which follows section of the hypoglossal nerve produces little disability, and can be minimized by joining the descendens hypoglossi to the cut peripheral end of the hypoglossal nerve so that junction of the hypoglossal and facial nerves is probably the better operation. The chief advantage of an anastomosis operation is the fact that it does not interfere with the middle ear. It can therefore be recommended for complete facial palsy with an intact tympanum as may occur after removal of a tumour of the cerebello-pontine angle or after some fractures of the base of the skull. *Results* *Disadvantages* *Chief advantage*

Synkinesia weakness in the other muscles. Some degree of synkinesia is seen in every case in which recovery occurs after a lengthy paralysis, whether an operation is performed or not. It is probably due to misdirection of single axons or entire nerve bundles, or to branching of regenerated axons, an anatomical consequence of degeneration which cannot be prevented (Fowler, 1939). Synkinesia and the related spasms can, however, be limited by encouraging the patient to

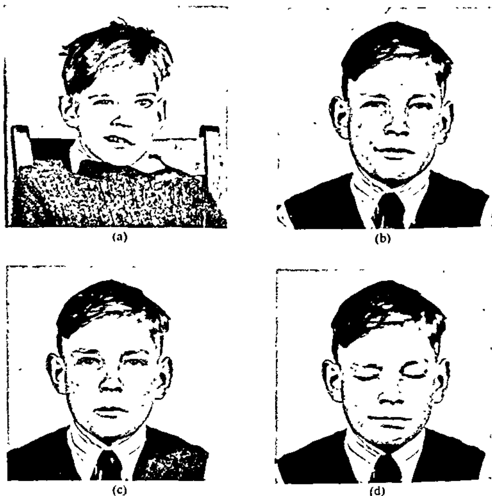


FIG. 9.—(a) Boy aged 7. Complete left facial palsy following a radical mastoid operation. Graft of 9 millimetres used to replace 5-millimetre loss of nerve substance. (b) Three years later, natural smile, equal palpebral fissures, drooping of angle of mouth. (c) Attempt at whispering shows weakness of upper lip and increased dimple in chin. (d) Minimal synkinesia on closing eyes.

restrict the range of movement on the sound side. Patients with expressive, mobile faces show greater synkinesia than the more impassive patients. It must be remembered that normal facial movements are association movements, in that different groups of muscles enter into the varying shades of facial expression. Pathological synkinesia is shown in minimal degree as retraction of the angle of the mouth on closing the eyes or narrowing of the palpebral fissure on showing the teeth, and does not mar the result. At its worst the entire facial musculature moves in a grimace with every movement.

Contractures with deepening of the naso-labial fold may occur after incomplete division of the nerve and after partial recovery; they may mask muscle weakness. With the return of emotional movements the patient will lose self-consciousness and embarrassment, so that the psychological benefit may exceed the anatomical and aesthetic standard of the recovery (Figs. 7, 8 and 9).

Contractures

Psychological results

11. ROLE OF PLASTIC SURGERY

The deformity of facial palsy can be mitigated by using fascial strips to support the paralysed muscles and to counteract the pull of the sound side. This is more successful than the attempt to restore movement by utilizing the temporal and masseter muscles. These fascial strips can be used for temporary support in place of intra-oral or external splinting. A small plastic operation such as tarsorrhaphy is sometimes valuable as an ancillary after a nerve operation when movement has returned, but asymmetry persists. Plastic surgery is useful for cases in which the central end of a divided facial nerve is inaccessible, as in some fractures of the base of the skull, after removal of a sequestrum of the petrous bone, and in some cases of operative injury or after an operation for a tumour of the auditory nerve. The results are generally superior to anastomosis with another cranial nerve.

Fascial strips

Temporary support

Finally a plastic operation is the only available treatment for reducing facial disfigurement when the muscles are so wasted and fibrotic that the galvanic response is absent. Movement cannot be restored but the worst features of the deformity can be masked and the patient feels more comfortable and less self-conscious.

Fibrotic muscles

12. ANASTOMOSIS OPERATIONS

When the central end of a divided facial nerve is not accessible for nerve grafting, improvement in appearance can be effected by anastomosis with another cranial nerve or by plastic surgery. Nerve anastomosis can restore tone to the facial muscles and provide symmetry at rest. Some degree of voluntary movement may be obtained but the emotional movements of facial expression are seldom if ever restored. The associated movements produced on voluntary movement vary; sometimes they are distressing and unsightly—a shrugging of the shoulder if the spinal accessory is used, or grimaces when swallowing if the hypoglossal is employed. These movements are said to diminish with time and are minimal when recovery of voluntary facial movements is limited. Loss of the accessory supply to the sternomastoid and trapezius leads to drooping of the shoulder; the atrophy of the corresponding half of the tongue which follows section of the hypoglossal nerve produces little disability, and can be minimized by joining the descendens hypoglossi to the cut peripheral end of the hypoglossal nerve so that junction of the hypoglossal and facial nerves is probably the better operation. The chief advantage of an anastomosis operation is the fact that it does not interfere with the middle ear. It can therefore be recommended for complete facial palsy with an intact tympanum as may occur after removal of a tumour of the cerebello-pontine angle or after some fractures of the base of the skull.

Results

Disadvantages

Chief advantage

Hypoglossal-facial anastomosis operation

An incision along the anterior border of the sternomastoid exposes the hypoglossal nerve below the posterior belly of the digastric muscle as it crosses the carotid sheath. The facial nerve is found at the upper end of the wound after it has emerged from the stylomastoid foramen and before it crosses the styloid process to enter the parotid gland. The branch which it gives to the posterior belly of the digastric should be followed back to the trunk. Before dividing the hypoglossal nerve a suture should be passed through the sheath of the peripheral end if a hypoglossal-descendens junction is intended. Junction of the two ends is best effected by means of concentrated fibrin suture (Young and Medawar, 1940) which minimizes scar formation. The posterior belly of the digastric must be divided before making the anastomosis and rejoined before the wound is sutured.

BIBLIOGRAPHY AND REFERENCES

Allen, A. G., and Northfield, D. W. C. (1944). *Lancet*, **2**, 172.
Ballance, C., and Duel, A. B. (1932). *Arch. Otolaryng., Chicago*, **15**, 1.
Collier, Josephine (1940). *Lancet*, **2**, 91.
Denny-Brown, D., Adams, R. D., and Fitzgerald, P. J. (1944). *Arch. Neurol. Psychiat.*, **51**, 216.
Discussion (1941). *Proc. R. Soc. Med.*, **34**, 575.
Duel, A. B. (1934). *Brit. med. J.*, **2**, 1027.
Fowler, E. P., Jun. (1939). *J. Amer. med. Ass.*, **113**, 1003.
Jefferson, G., and Smalley, A. A. (1938). *J. Laryng.*, **53**, 417.
Morris, W. M. (1938). *Lancet*, **1**, 429.
Weddell, G., Feinstein, B., and Pattle, R. E. (1944). *Brain*, **67**, 178.
Young, J. Z., and Medawar, P. B. (1940). *Lancet*, **2**, 126.

[References to other titles are given under Facial Palsy in the Index Volume.]

FACIO-MAXILLARY INJURIES AND DEFORMITIES

By RAINSFORD MOWLEM, F.R.C.S.
Plastic Surgeon, Middlesex Hospital; Surgeon-in-Charge, Plastic Unit, Hill End Hospital (E.M.S.), St. Albans

AND

B. W. FICKLING, F.R.C.S., F.D.S.Eng.
Dental Surgeon, Royal Dental Hospital of London; Dental Surgeon, St. George's Hospital; Dental Surgeon, Maxillo-Facial Unit, Hill End Hospital (E.M.S.), St. Albans

PART I

FACIO-MAXILLARY INJURIES

PART II

DEFORMITIES

PART I

FACIO-MAXILLARY INJURIES

1. INTRODUCTION

148.] In the face, tissue losses or even linear wounds may produce distortion and disfigurement out of all proportion to their dimensions. The choice, both of the method and of the materials for repair, is important.

2. GENERAL TECHNIQUE

(1) Suture material

The function of a suture is approximation and not the creation and subsequent resistance of tension. Accuracy of insertion is more important than tensile strength. For the skin, the material of choice is braided silk, 0·006 inch and 0·009 inch, whereas for the subcutaneous tissue plain catgut 3/0 or 4/0 *B.P.C.* is used.

(2) Split-skin grafts

When tissue has been lost it must be replaced either by flaps from the immediate neighbourhood or by the importation of tissue from elsewhere on the body. The simplest method of repair is by a free skin graft.

Primary and definitive repair

Split-skin grafts are almost universally applicable as a method of primary repair and are often the choice in definitive repair. Their colour may not approximate accurately to that of the recipient area and they tend to contract, these characteristics depending to some extent upon their thickness. The thicker they are the less they show these defects. They are applicable to infected wounds but, if the organism is not sensitive to chemotherapy and is productive of much exudate, it is better to apply them in postage-stamp size rather than in large sheets.

(3) Technique of split-skin grafting

The best instrument for free hand cutting is either a Blair knife or a Humby knife, but the ordinary razor is effective for small grafts. A common donor area is the inner aspect of the arm, but larger grafts can be cut from the medial or lateral aspects of the thigh.

A piece of wood, 9 inches × 2 inches × ½ inch, is held in the left hand and applies gentle pressure to the skin to create a little tension about ½ inch in front of the cutting edge of the knife. The cutting itself is done by an easy sawing movement of the knife. An advance of $\frac{1}{16}$ inch for each sweep of the knife is ample.

Use of tulle gras

Application under pressure

The skin so obtained is most easily handled by being spread on Vaseline net (tulle gras), care being taken to keep its raw surface uppermost. The graft need not be shaped to the exact size of the defect; any excess will overlap normal skin and may be easily clipped away at the first dressing. It should be applied under pressure to the recipient area, and the method whereby this is obtained must vary in accordance with the site. A common method consists in tacking the skin graft into position by a few marginal stitches the ends of which are left long so that they can be subsequently tied over a thick pad of cotton-wool moistened with paraffin-flavine emulsion or normal saline. The wool pad is finally pressed firmly into position, either by Elastoplast strapping or by crêpe bandaging, and this pressure should be maintained for from 5 to 10 days. If the recipient surface is infected it can be "frosted" with penicillin or sulphanilamide powder, and the graft applied directly over it.

Complications resulting from infection

When the area is infected with non-sensitive organisms such as *Bacillus proteus* or *Pseudomonas pyocyanea*, the graft will tend to fail because the amount of exudate produced by these organisms tends to float it off. It is then preferable to apply the skin in small squares or strips, the margins of which are about ⅛ inch apart, so that any exudate readily finds an exit.

Injection of thrombin

The injection of thrombin (500–1,000 units per cubic centimetre) beneath the graft is an additional factor in ensuring its adhesion, but large quantities of this material should not be left to create a dense clot.

Alternatively a Padgett dermatome may be used to cut the graft. In this case there is greater latitude in the choice of donor area. The drum of the instrument adheres to the skin by rubber cement, and the cutting edge can be adjusted to produce grafts of the required thickness (Padgett, 1944 and 1946). The graft so obtained is commonly thicker than that resulting from free hand

cutting, and should be shaped to fit the defect very accurately. Many marginal sutures will be required to ensure apposition, but in other respects the fixation of the graft is as described above.

The donor area of any type of split graft is covered with a tulle gras dressing and left undisturbed under a firm bandage for from 10 to 14 days.

(4) Whole-thickness skin grafts

Whole-thickness skin grafts give better cosmetic results and tend to contract less than split-skin grafts. The technique of application, however, is more tedious and their chance of complete success is less than that of the thin grafts. They do not withstand infection and their use is confined to areas in which either appearance or freedom from post-operative contracture is essential; for example, the face and hands.

Technique

An accurate pattern of the defect is cut in jaconet and outlined on the donor area. The graft is dissected off with an ordinary scalpel and must include nothing other than skin. Complete haemostasis of the recipient area is obtained, and the graft is then sutured into position so that it has perfect marginal apposition. Pressure is applied and maintained for from 7 to 14 days.

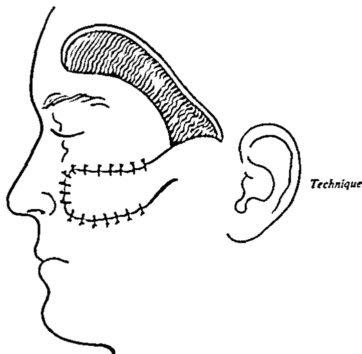


FIG. 10.—A flap of skin and subcutaneous tissue, with an adequate blood supply through its attached base, has been transposed from the forehead to fill the defect in the cheek. The forehead is repaired at the same stage by a free skin graft.

Healing of the donor area

The donor area cannot heal except from its margins and, should it be of any size, is best closed either by approximation of its margins or by the application of a split graft from elsewhere.

(5) Pedicles and flaps

Maintenance of blood supply

When both skin and subcutaneous tissue are to be imported their blood supply must be maintained throughout all the stages of transference. When the donor and recipient areas are or can be brought into close approximation a direct flap is available—part of the forehead can be swung down to reconstruct the cheek. The flap is so designed that its base transmits sufficient blood supply to the freed portion (Fig. 10). After about 3 weeks a good blood supply will have grown into the transposed skin from the recipient area, and any necessary modification of the original vascular bridge can be carried out.

Use of an intermediate vehicle in maintaining blood supply

Occasionally an intermediate vehicle is used to maintain the blood supply—a flap from the abdomen may be brought up to the cheek by using the arm as an intermediate host.

Formation of a tubed pedicle

When the donor and recipient areas are some distance apart it may be desirable to eliminate all chance of infection by converting the required tissue into a tubed pedicle before transferring it. For example, if skin and subcutaneous tissue from the chest is required to replace a defect on the neck or the face, the first stage is to raise a strap by two parallel incisions in the acromio-thoracic region. After undermining, the edges are approximated to make a skin-covered tube. The donor area is closed either by a suture or by a split-skin graft (Fig. 11). About 3 weeks later one end can be swung into its new position and a similar interval separates all subsequent stages (Gillies, 1939).

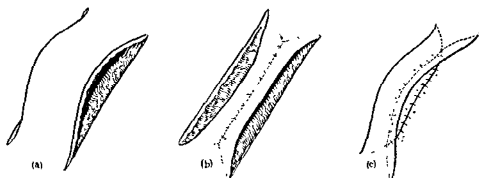


FIG. 11.—*The parallel incisions at* (a) *reach to the deep fascia. At this level the skin is converted into a strap and then into a tube* (b). *Closure of the donor area is shown at* (c).

By one or more of such procedures most soft-tissue lesions of the face can be made good, but it is usually advisable to delay such final repair until all deep fibrosis from the original injury has absorbed.

3. GENERAL CONSIDERATIONS

Oedema masking bony displacements

Minor skin and subcutaneous lesions may well overlie extensive skeletal damage, and the oedema which follows injury tends to disguise bony displacements the possible presence of which must be eliminated by careful examination (*see* p. 27). The essential prerequisites for operation are, first, recovery of the patient from the initial shock, and secondly, the availability of a skilled anaesthetist. The patient must be protected from the inhalation of blood from his upper respiratory passages before, during and after anaesthesia. Whilst he is in bed this can be ensured by his position. During his anaesthetic induction careful toilet of the nose and pharynx with a suction nozzle is essential. Once the intratracheal tube is in position an efficient pharyngeal pack gives added protection.

(1) Recent injuries: soft tissues

(*a*) *Abrasions*

Marring effect of indriven pigment

Abrasions are commonly acquired on dirty road surfaces. The lesion itself is unimportant, but the pigment which is driven into it is important, for unless it is removed immediately it will become incorporated in the final scar and, however good the texture of this may be, the cosmetic result is poor. When

healing has occurred the only possible method of treatment will be removal of the whole area and extensive repair. At the time of the accident, however, it is possible to cleanse the wound completely. This is best done by soaking with Vaseline or some similar grease, waiting for a few minutes, and then cleansing with a mild detergent or soap and water. An application of sulphanilamide or penicillin may be used to control infection, and the resultant scar should be minimal.

(*b*) *Lacerations*

Trimming of the margins is justifiable only when the skin edge is so damaged that its viability is in doubt, or when the defect is so ragged that accurate approximation is impossible. A strip not more than ⅛ inch wide is the maximal amount which should ever be removed. Complete haemostasis is essential, but there are few vessels in the face which require ligation. Most of them, if accurately picked up, will respond to "twisting off".

The component layers of the wound are repaired separately, and the skin edges accurately apposed by small stitches which should not include a "bite" of more than ⅛ inch. Such accuracy will enable the sutures to be removed on the third and fourth days.

(*c*) *Actual tissue losses*

Round the eyelids, the alar margins and the mouth, loss of even a small amount of tissue will result in secondary distortion. Direct approximation of the edges of the defect is often impracticable without causing tension. Local flaps of skin may be sufficient to provide complete relaxation; if not, then more skin in the form of a free graft should be imported. In the first instance this graft can well be only split-thickness, and may come from the arm or the thigh. The chances of success of such a graft are higher than those of a full-thickness graft, though the cosmetic value is less. At this stage primary epithelialization, with its consequent avoidance of sepsis and distortion, is more important than appearance. *Secondary distortion*

In some instances, such as a dog-bite of the lip, it may be justifiable to sacrifice part of the underlying tissue and thereby convert the irregular skin loss into a full-thickness surgical excision. Subsequent repair in layers will give a symmetrical lip, provided that the loss does not exceed about a quarter of the total length of the lip. When the loss is greater than this, and when the lesion extends through the full thickness of the cheek itself, it is preferable not to attempt immediate repair but rather to epithelialize the margins of the defect by suture of the surface skin to the lining mucosa. This will avoid infection and further tissue destruction, will maintain normal structures in their correct position, and will thereby simplify the final repair and accelerate the time at which it can be carried out. *Epithelialization of margins of defect*

Such a technique is applicable also to losses of the full thickness of the nose and cheek, and should always be carried out unless all the facilities for a definitive repair are available.

(2) Old lesions: soft tissues

(*a*) *Scars*

Scars may need treatment because they contain ingrained pigment, because they are hypertrophic and irritable, because they cause distortion of adjacent

Scars

structures or because of their poor appearance (*see* Cicatrices, including Keloid, Vol. 3, p. 56).

(*b*) *Tissue losses*

These losses will demand the importation of new tissue, and the method to be used must depend upon an accurate estimate of the actual degree of loss both in area and in depth. The first stage in the repair may be the complete excision of all scar and the restitution of the surrounding distorted tissues to their correct position. After such a definition of the loss the repair may sometimes be completed at the same operation, but it may be necessary to deal with the problem in two or more stages.

The shallowest lesions will obviously concern skin alone. Appearance and function are now the essentials and, because infection is no longer a danger, whole-thickness grafts are the method of choice. The post-auricular area will

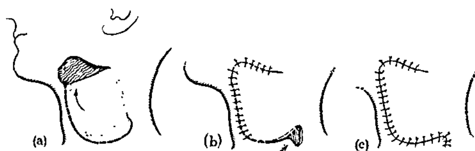


FIG. 12.—The defect in the hair-bearing skin over the mandible is closed by rotating a flap from the neck. Stippling shows the necessary undermining. A small secondary defect will occur in the neck and is closed as indicated by the arrow (b).

provide a reasonable amount of skin which is an excellent match in colour and texture for all parts of the face except the hair-bearing areas. Larger amounts of skin are best obtained from the inner aspect of the arm. Hair-bearing free grafts are satisfactory only if they are small and their use is confined to eyebrow reconstruction. The replacement of loss of hair in the beard area is practicable only by means of local flaps which in effect transpose the defect so that it comes to lie below the collar line, where the presence of a hairless graft will be unimportant (Fig. 12).

(i) *Losses of skin and subcutaneous tissue.*—Some of these can be made good by tissue derived from the immediate neighbourhood. Such a repair can be carried out by swinging a flap from the neck to the chin or the cheek, whilst another example is the use of the forehead to reconstruct the upper part of the cheek or the nose or even the chin. These flaps will obviously create secondary raw surfaces in the area from which they are raised and the epithelialization of these will often call for a skin graft (Fig. 10) although secondary skin closure is sometimes possible (Fig. 12).

(ii) *Losses of skin, subcutaneous tissue and mucosa.*—If such a lesion has had adequate primary treatment (p. 21) the margins of the defect will consist of a suture line between the skin and mucous membrane. The size of the defect will be obvious and the type of reconstruction necessary to replace all three layers will be evident. Three main methods are available.

(1) The transposition of a full-thickness flap from the immediate neighbourhood with secondary suture of the defect so created. The most common injury requiring such a repair is loss of part of a lip which can be made good by rotation into it of a full-thickness segment of the adjacent cheek or upper lip.

(2) The provision of lining by inturning flaps of skin based on the margins of the defect, to replace the lost mucosa. This is followed by the provision of

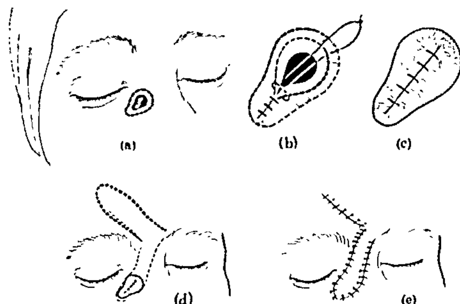


Fig. 13.—Detail of closure of a nasal fistula by inturning and suturing the epithelial margins. The surface defect is covered by a flap from the forehead which in this case has been inset along its full length. Closure of the donor area has been effected by direct approximation. (b) and (c) are slightly enlarged.

skin and subcutaneous tissue either as a local flap or as a pedicle arising elsewhere (Fig. 13).

(3) The importation of new lining as well as cover. This may be done by inturning a pedicle to provide both lining and cover, by the prior insertion of a skin-graft lining beneath the pedicle, or by the use of two separate pedicles, one for lining and one for cover.

After the completion of the necessary soft-tissue repair, skeletal reconstruction may still be necessary.

4. BURNS

(1) Treatment of facial burns

(*a*) *General*

Burns confined to the face may not cause systemic disturbances, but whenever necessary haemoconcentration and toxaemia must be dealt with, and the alleviation of pain is essential (*see* Burns and Scalds, Vol. 2, p. 518).

The probability of burning of the mouth and air passages and of later oedema of the larynx and trachea must always be remembered.

(b) Local

The ultimate treatment of the burn will depend upon its degree, and except in the very slight or in the very severe cases this cannot be assessed until about the fourth day. For most patients, therefore, early treatment is expectant and is directed towards the avoidance or elimination of infection. Rest, sedatives and warmth are essential. Oedema can be minimized by allowing gravity to assist in draining the affected part.

Rest, sedatives and warmth

Infrequent dressings

Trauma from dressings should be avoided both by the nature and the infrequency of the dressings themselves. Perhaps the best primary treatment to the local area consists in a liberal application of penicillin or sulphanilamide cream beneath a light mask which should not need replacement more frequently than once in 24 hours. When it is to be replaced it must be soaked off. Frequent swabbing of the eyes, nasal orifices, lips and ears will add to the patient's comfort and decrease the possibility of the spread of infection from these areas. If infection is allowed to occur it may well destroy the few intact skin elements which have escaped initial destruction, and thereby convert a partial loss into a complete one. This alters the prognosis from one of spontaneous regeneration to one in which grafting is the only method of avoiding gross contractures.

The corneae are rarely severely damaged by the burn but are very liable to ulceration from exposure during the first 2–3 weeks of recovery. Chemical burns may sometimes damage the corneae and, if so, immediate protection by special contact lenses may be necessary.

Possible perichondritis

Special attention to the ears is desirable as the skin over them is relatively thin, and its complete destruction exposes cartilage. Infection is then very likely to occur, and will result in perichondritis which is not only very painful, but is almost inevitably followed by loss of the cartilage itself and collapse of the auricle. At the first sign of perichondrial infection the institution of extensive drainage appears to be the only method of avoiding complete destruction.

Chemotherapy

Before the end of the first week the diagnosis of the degree of skin loss should be clear. If it is partial the conservative regimen is continued until healing is complete. If there are areas of complete skin destruction the aim is to produce a clean granulating surface upon which a split-skin graft can be expected to succeed at the earliest moment. This may necessitate the use of normal saline or eusol packs to encourage slough separation. Upon occasion surgical excision is also practicable. When the area is clear of dead tissue its bacteriology should be investigated, and penicillin or sulphanilamide should be used if sensitive organisms are present. As soon as such organisms are under control split-skin grafts should be applied.

(2) Treatment of late results

Even when spontaneous healing occurs it may be associated with contracture. This may cause ectropion of lids or lips, and distortion of the mouth or nose (*see* Eyelids, Vol. 3, p. 509).

(a) Nose

The commonest defect resulting from burns is loss of skin and subcutaneous tissue, particularly at the alar margins which become everted and thin.

Replacement by a free skin graft is seldom possible and complete reconstruction of the alar margins and of the skin covering the nose, by means of a flap derived from the forehead or from the acromio-thoracic region, is often necessary.

(*b*) *Mouth* (*upper lip*)

Ectropion can frequently be cured by full-thickness grafting, though the donor area should be the arm or the abdomen as insufficient material is available behind the ear. Accuracy of suture, maintenance of pressure and avoidance of infection are essential.

(*c*) *Mouth* (*lower lip*)

This does not respond quite as satisfactorily to free grafting as does the upper lip, and replacement of the whole burnt area of chin by a pedicle derived from elsewhere is often preferable.

(*d*) *Neck*

Occasionally a burn will result in a vertical band-like contracture. When the texture of the burn scar has returned to normal, that is, when it is no longer vascular, it may be possible to use this material for the purposes of repair by means of a "Z" plasty (Fig. 14). This, in effect, transposes the tension from the vertical to the horizontal and increases the vertical extent of the skin available on the front of the neck.

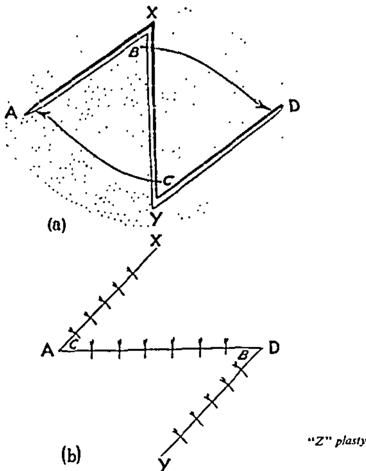


Fig. 14.—The original tension band lies between X and Y; it is split along its length and the stippled area is undermined. The incisions AX and DY create triangular flaps which are transposed as shown at (b).

"Z" plasty

When the loss is wider than a mere band, downward retraction of the chin to the region of the sternum is common. The amount of skin to be imported to correct this is often as much as 50 square inches, and this can be obtained most satisfactorily by a pedicle from the abdomen or the chest. Free grafting in this area is not altogether satisfactory as there is a very great tendency for the graft itself to contract and thereby minimize its value. In addition to this, fixation is difficult as each movement of swallowing tends to disturb the apposition of the graft to the recipient area. *Fixation difficult*

5. SKIN LOSS FROM DISEASE

(1) Lupus

Both lupus erythematosus and lupus vulgaris commonly affect the face. The former is usually distributed in the typical butterfly pattern across the nose with extensions on to the cheeks and sometimes on to the forehead and inner parts of the lids and eyebrows. The latter is more diffuse and may occur anywhere, though very frequently it is associated with intranasal lesions. Surgical excision of both types appears to be satisfactory, but the erythematosus type is less prone to recur than is the vulgaris type. In either case a fairly wide margin of normal tissue should be included in the excision and an immediate split-skin graft should be applied. The newer methods of systemic treatment should always be tried before recourse to surgery.

Surgical excision

The problem of fixation and pressure is often difficult, and considerable ingenuity is required to effect pressure without occlusion of nostrils, eyes or mouth. In both types of lesion a preliminary course of treatment by penicillin, either systemic or local, will help to clear associated secondary infection and render the chances of a successful graft much greater. In some of the more advanced cases complete surgical removal of the whole affected area may be impracticable, but it is always possible to graft the lids to correct ectropion. This graft will generally be satisfactory, even though active lupus may still lie on its lower margin.

(2) Syphilis

Perhaps the commonest lesion affecting the face is intranasal ulceration resulting in loss of definition of the nose. The overlying skin often escapes, but is drawn into the nasal cavity by contraction of the scar which replaces the septum and its muco-perichondrium.

Transbuccal incision

Normality can be restored by a transbuccal incision behind the upper lip, which is extended to free the skin from its deep adhesions. The resultant defect is skin-grafted and maintained in the distended state for about 6 months (Gillies, 1935). Support for the bridge is then supplied by a prosthesis carried on the upper denture, or by a bone or cartilage graft (Mowlem, 1941a).

(3) Malignant neoplasms

Wide excision of malignant conditions may result in complete loss of part or all of any of the facial features. If care has been taken to epithelialize the margins of such a defect at the time of the radical operation, there should be no distortion of the surrounding normal tissue. The repair of these lesions should be deferred for at least 12 months during which time a prosthesis may be worn. In the great majority of cases repair will entail the importation of new tissue from elsewhere, and the necessity for providing new lining for any of the facial cavities must not be overlooked.

Deferment of repair

6. LESIONS OF THE FACIAL SKELETON

In many instances bony damage is not necessarily associated with severe overlying soft-tissue lesions. Fractures and displacement are almost invariably disguised by a considerable amount of swelling of the overlying tissue,

and for this reason, as well as because of the fact that they are often associated with more urgent damage, their diagnosis may be overlooked. Sometimes this means that their treatment will have become impossible even when they are recognized. The coexistence of head injury often focuses all the attention upon this aspect, and it is difficult to decide whether or not to risk aggravation of the general condition by fixation of the facial fractures. The risk appears to be small and is worth while if reduction of the fractures reduces peripheral irritation. It must also be remembered that gross displacement of the maxilla can produce such severe dysfunction in the airways and in dental occlusion as to make the patient's life a misery. Such displacements are often reducible only in the first few days after injury, so that it may be preferable to accept an early surgical risk in order to obtain a better final functional result. When the facial skeleton is injured the fracture lines may extend into the orbit, the cranium, the nasal cavity, the antra, the ears or the mouth, and signs and symptoms arising from these involvements will often assist in early diagnosis.

Assessment of risk entailed in early surgery

(1) Surgical and dental co-operation

Surgical, mechanical and aesthetic problems arise in the treatment of jaw injuries, and correlation of these various factors is of the greatest importance. The co-operation of a dental surgeon should be sought at the earliest opportunity. Immobilization of the jaws in dental occlusion assists in correct reduction of bony deformities, and provides support for displaced soft tissue. It is always easier to achieve dental fixation before lacerated soft tissue is approximated; in fact, when dental fixation follows surgery, the necessary manipulations commonly result in a breakdown of suture lines.

Early immobilization of jaws indicated

(2) Routine examination

It is preferable to stand behind and above the patient, so that the frontal and supra-orbital regions, which are seldom grossly involved, can be used as a base-line for purposes of comparison. Both hands are used simultaneously, and examination commences in the glabellar region, continues down the nasal bridge to note deviation or depression, and then returns to trace along the infra-orbital and lateral orbital walls. The upper margin of the zygomatic arch is traced backwards, then the finger returns forwards to the malar and thence on to the anterior wall of the maxilla. The mandibular condyles are palpated just in front of the tragus, where their forward movement can be felt readily as the jaw is opened, and from this point the subcutaneous margin of the bone is palpated as far forward as the symphysis menti. It is usually possible, even in the presence of extensive swelling, to distinguish asymmetry between the two sides.

Position of examiner

Recognition of asymmetry

Finally, a careful examination is made within the mouth. Laceration of mucous membrane, submucous ecchymosis, abnormal mobility and changes in alignment are common signs of fractures of the jaw, which, by careful manipulation, can often be prevented from becoming compound. Teeth are frequently loosened or partially dislocated in facial injuries, but careful examination will indicate those cases in which there is a fracture of the jaw in addition.

(*a*) *Dental occlusion*

When teeth are present the most important sign of fracture of the jaws is a disorganization of the dental occlusion, that is, the teeth do not meet together in the usual manner. In one position, which is usually when the jaws are approximated most closely, the biting surfaces fit together with maximal comfort and contact. Inability to make the jaws meet in correct occlusion, a fact very apparent to the patient, is the most sure sign of injury of the teeth or of the jaws carrying the teeth. The occlusion is the best guide to correct position, and is far more exact than radiography.

Occlusion the guide to correct position

(*b*) *X-ray examination*

The 30° and 60° occipito-mental views are most valuable in lesions of the upper face, the nasal and zygomatic bones being especially well visualized. Antero-posterior views provide confirmatory evidence, and a true lateral skiagram may help in assessing displacements of the entire maxillary block. Fractures of the maxillae are not well demonstrated radiographically unless there is very gross displacement, but good films will usually show a loss of continuity in the inferior orbital margin or the lateral antral wall. Antero-posterior and oblique lateral views of the body and ramus will reveal most mandibular fractures.

Intra-oral films

Intra-oral occlusal views are of the greatest help in determining the position and displacement of fractures near the front of the mouth, whereas dental films are required to demonstrate injuries to teeth and their relation to fracture lines.

7. FRACTURES OF THE NASAL BONES

Alteration in contour of nasal bridge

Fractures of the nasal bones are characterized by immediate alteration in the contour of the nasal bridge. This may be associated with bleeding, with external swelling and with a greater or lesser degree of nasal obstruction. Minor injuries from the side will result in a shift of the nasal bones to the opposite side. The septum will retain its attachment to the nasal bones and be displaced with them. More extensive injuries are caused by direct blows from in front, which result in comminution of both the nasal bones and the septum so that the bridge line is depressed and considerably widened. In both types of injury there may be associated bruising of the eyelids and subconjunctival haemorrhage which is usually confined to the medial third of the sclera.

Associated injuries

Treatment

Full general anaesthesia

Full general anaesthesia is required, and it is safest to employ an endotracheal tube introduced through the mouth, with a pharyngeal pack to protect the patient against the entrance of blood into the lungs. The twin flat blades of an Ash's forceps are inserted along the floor of the nose and are slowly swept in an arc to the region of the nasal bridge. This will reduce the overlap of any fracture of the septum and will carry the remnants of the nasal bones forward into correct position. It may be necessary to disimpact the nasal bones themselves from the fracture line in the region of the frontal process of the maxilla. In all but the most minor instances this will be best carried out by the insertion of one blade of Walsham's forceps into the nasal cavity, whilst the other lies on the overlying skin. Both disimpaction

and restoration of normal position can thus be carried out. Splintage is unnecessary unless there is extensive comminution, when the bones can be persuaded to stay in their normal position by transfixing the nose immediately below the margins of the nasal bones with a heavy silk mattress suture tied over pressure pads. If such pads are used, they should not be retained for more than 4 or 5 days, as stitch marks are very prone to remain.

Splintage usually unnecessary

Intranasal packs are seldom useful and always dangerous, but rubber-covered metal suspension rods have their uses.

In the most extensive nasal fracture the ethmoids themselves are impacted and displaced laterally. This results in hypertelorism. Unless this condition is attacked within about 48 hours it can seldom be cured. Treatment is as before except that the finger and thumb are introduced as far as possible into the soft tissues of the orbit, in order to squeeze the comminuted mass of bone into something approaching its correct position.

Hypertelorism after extensive nasal fracture

With this exception most fractures of the nose are capable of reduction at any time up to 14 days after injury.

8. MALAR-ZYGOMATIC FRACTURE

(1) Signs and symptoms

The prominence of the cheek bone on the affected side is lost in such a fracture. There is very frequently subconjunctival haemorrhage in the outer and lower quadrant of the eye on the affected side. The patient may complain of diplopia, which is stated to be due to loss of support of the eye but is more probably secondary to imbalance of the ocular muscles, caused by interference with the inferior oblique. There may be anaesthesia in the area supplied by the infra-orbital and anterior superior dental nerves, for the fracture often involves the infra-orbital canal. Pain on mastication and inability to close the jaw are due to pressure of the displaced zygomatic arch on the temporalis or more rarely on the coronoid process.

Subconjunctival haemorrhage

(2) Treatment

Two main methods of approach are available.

(a) If the zygoma is fractured and displaced as one piece, the simplest method of approach is through an incision about 1 inch long in the temporal hair line. The temporal fascia is exposed and incised. A straight elevator is passed downwards deep to the fascia but superficial to the muscle, until it comes to lie beneath the zygomatic arch. Leverage with an external controlling finger is then sufficient to restore the position, which in most cases requires no maintenance. Disimpaction may require a considerable amount of force. A similar approach is obviously the ideal for a fracture confined to the zygomatic arch. (Gillies, Kilner and Stone, 1927.)

Incision in temporal hair line

(b) When there is gross comminution of the zygoma as a whole such an approach will not give control. An incision is made in the buccal sulcus on the affected side down to the anterior wall of the maxilla. A fracture line will invariably be found beneath this incision. One or two small fragments of the anterior wall of the antrum may be removed, and once the antrum is thus opened an instrument, or preferably a finger, may be passed into it, and the orbital floor and the lateral antral wall can be ironed out into their correct

Incision in buccal sulcus

position. The fragments will seldom remain in position without further support, and this is obtained by packing the antrum with 1-inch gauze soaked in paraffin-flavine emulsion or penicillin cream. If a small drainage tube is inserted first and the pack put in round this, one is enabled, even when the pack is in place, to insert an instrument and obtain more elevation at any point which has not been restored to its normal position. The pack and tube are maintained for from 10 to 14 days. In some of these cases the antral fistula tends to persist and if, 2–3 weeks after the removal of the pack, this is the case, it is desirable to reopen the antrum, inspect it for small sequestra, and carry out an extensive intranasal antrostomy through which irrigation and medication can be applied.

Intranasal antrostomy if antral fistula persists

In most cases in which there is diplopia, and in all cases which show infra-orbital anaesthesia, reposition of the fragments is not followed by an immediate recovery of these symptoms but, if the restitution has been adequate, both of them should clear up within 2–10 weeks.

In delayed cases up to, say, 2 months, such methods may be ineffectual because the defects between the displaced bone surfaces are filled with fibrous tissue. This is removed through incisions over the fracture lines in the lateral orbital wall and the infra-orbital ridge.

Maintenance of the correct position, even if obtained, will cause difficulty, and it may be necessary to have recourse to actual wiring across the fracture lines. On rare occasions it may be desirable to obtain external control by inserting a screw or encircling the fragment with a wire. The outstanding ends are then fixed to a plaster head-cap or to a bar emerging from splints on the upper teeth.

9. FRACTURES OF THE JAWS AND TEETH

(1) Mouth hygiene

Most severe fractures of the jaws are compound into the mouth, and teeth are commonly fractured or dislocated. The reflex inhibition of swallowing and of coughing and the self-cleansing movements of the mouth lead to an accumulation of debris and inspissated saliva which is aggravated by mouth breathing. There is a rapid increase and probably a change in the bacterial flora resulting in the condition of "foul mouth", which is a common clinical experience. Under these conditions mandibular fractures readily become infected (*see* p. 42). Regular, skilled cleansing of the mouth will go far to prevent this deterioration in oral hygiene, but reduction and immobilization of the fracture is essential before the condition can be eliminated. No person with a severe compound fracture of the mandible will achieve any treatment of value if handed a routine ward mouth-wash. The administration of penicillin, either local or general, is a useful prophylactic measure.

Reflex inhibition of swallowing and coughing

(2) Bandages

It is important to appreciate that bandaging will support, but will not immobilize, the mandible. Such support is of value as a first-aid measure and is all the treatment required for minimal fractures, especially in old people with edentulous jaws. The four-tail bandage, which increases most of the normal displacements, should be discarded in favour of the barrel bandage or its variants, which have a more vertical lift. The most effective support is

Barrel bandage

provided by wide elastic or rubber tissue slung beneath the chin and hooked to an adjustable headband or plaster cap.

(3) Methods of reduction

Reduction may be immediate or gradual, depending upon the type of lesion, the interval after injury and the method of fixation. Early treatment allows immediate reduction, usually under anaesthesia. It may not be possible to correct all displacements of cases treated late, even at operation, and elastic *Immediate or gradual*

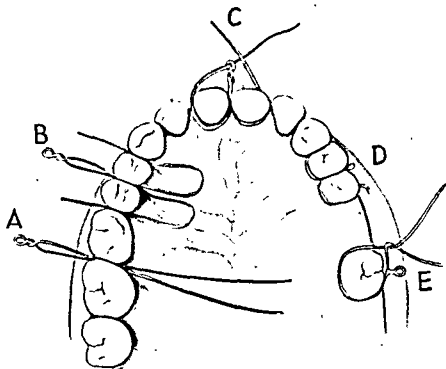


Fig. 15.—A, B, C, D, are stages in the application of an eyelet wire. E: One method of applying an eyelet to a single tooth. Using brass wire, the eyelet is touched with soft solder to prevent it untwisting.

or weight traction is required. Fractures of the maxillae are usually reduced under full anaesthesia as soon after injury as conditions permit, but gradual reduction of mandibular fractures by elastic traction is commonly practised, especially in the less severe cases.

10. METHODS OF IMMOBILIZATION

If teeth are present in both jaws, one of which is uninjured, the latter provides a perfect anatomical splint. Maxillo-mandibular fixation in correct occlusion is thus generally employed by one of the methods described below. Similar treatment is effective for many fractures of the angle and ramus, but in certain cases the line of fracture facilitates displacement by muscle action (*see* p. 40), and additional methods of immobilization, as by pin fixation, are required. Edentulous jaws provide a separate problem (*see* p. 41). *Maxillo-mandibular fixation* *Pin fixation*

(1) Eyelet wiring

When there are sufficient teeth in each jaw to permit stable occlusion of each fragment, wiring gives excellent results (James and Fickling, 1940). It is particularly valuable as emergency treatment, for suitable wire is available in most operating theatres, and there is no delay as with cap splints. Stainless-steel or brass wire, 0·015–0·02 inch, is employed. Eyelets are made by twisting small loops in the centres of 6-inch lengths of wire. These are applied with curved Spencer Wells forceps to pairs of teeth in each jaw, in the manner shown in

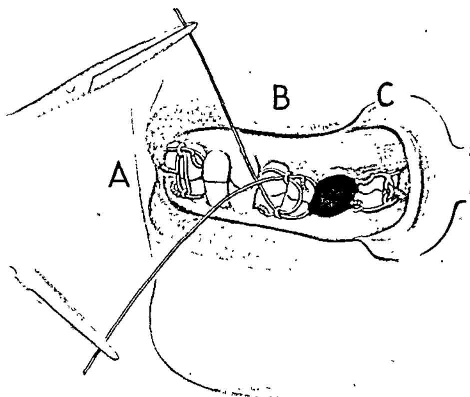


FIG. 16.—Application of fixation wires. A, B, C illustrate stages of application.

the diagram (Fig. 15). Maxillo-mandibular fixation wires are then passed through an eyelet in each jaw, the fractures correctly reduced, and the wires twisted tight (Fig. 16). The eyelets should be so placed that each fragment, when possible, has two fixation wires, one forward and one backward. The same eyelet may be used for two fixation wires in V formation. It is preferable, but not essential, to apply eyelet wires under full anaesthesia, a tongue stitch being inserted and the throat pack removed before the fixation wires are tightened.

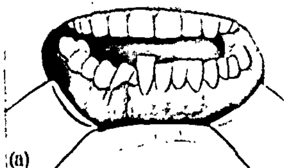
ll aesthesia sirable

Modifications

When a single tooth has to be wired, a small watch-chain link can be threaded on the wire, or the eyelet passed twice round the tooth. When emergency wiring is necessary but the teeth are spaced, lengths of thicker wire, 1–2 millimetres, are bent to the arch and wired to the teeth (Buxton, Parfitt and MacGregor,

1941). This permits fixation wires to be attached to the arch in the gaps where teeth are absent.

Arch wires



(2) Cast metal cap splints

Fixation by metal cap splints, cemented to the teeth of both jaws, is the method of choice for maxillary fractures, mandibular fractures with gross displacement and most fractures in children. Impressions of the teeth are taken, preferably without an anaesthetic, a stage which is well tolerated by almost all patients, including children and those with severe injuries. Using the models thus prepared, separate splints are cast to fit the teeth on each fragment, with attachments to carry hooks for rubber-band traction, or loops for cheek wires. If threaded plates are attached to the splints, a rigid bar can be soldered to the removable plates and screwed to the splints, thus further reducing movement at the fracture line (McLeod and Shepherd, 1941; Fickling, 1946) (Fig. 17). When facilities for metal work are not available, cap splints

Impression of teeth taken

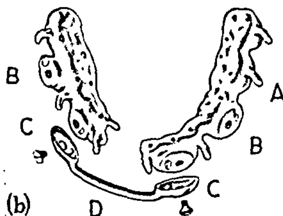




FIG. 17.—(a) Fracture of mandible in right canine region; (b) cast metal cap splints prepared for right and left fragments. A: Hook for rubber-band fixation to maxillary splint (not shown). B: Screw plate for fixation to maxillary splint. C: Screw plate, locking plate and screw. D: soldered bar joining these and providing rigid fixation across the fracture. (c) Skiagram of the fracture.

can be made of acrylic denture material, although this has many disadvantages.

(3) Pin fixation

The adaptation of the crossed-pin technique to facial injuries has made possible the fixation of fragments not bearing teeth, and is thus particularly valuable in fractures of the edentulous mandible (Fig. 18), and for the immobilization of the angle and ramus (Mowlem, 1941b; MacGregor, 1945). The method depends upon the principle that if two pins are inserted into bone at an

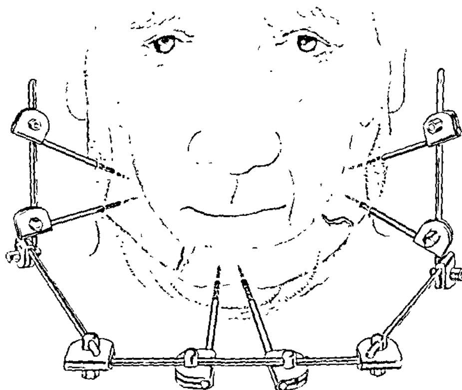


FIG. 18.—Pin fixation applied to the three main fragments in a bilateral fracture of the edentulous mandible.

angle of 60° and the outer ends clamped together, an effective grip of the bone is obtained. *Endotracheal anaesthesia* Under endotracheal anaesthesia, the margins of the mandible and the line of fracture are outlined on the skin with ink. The pins, trocar-pointed, 2–3 millimetres of stainless steel or vitallium, are passed through a small skin incision and inserted with a bone drill or an Archimedean drill, avoiding heating, until the point is felt to grip on the inner alveolar plate. It is usual to penetrate right through the ramus to obtain the necessary hold. The site of election is ¼ inch from the inferior or posterior surface of the bone. The inferior dental nerve and tooth roots must be avoided, and the pins should not, when possible, be within 1 inch of the fracture. Two such pins are inserted in each main fragment and united by a clamp or bar, with universal joints of special pattern. *Reduction by intra-oral and extra-oral manipulation* The fracture is then reduced by intra-oral and extra-oral manipulation, while an assistant attaches ⅛-inch rods to the pin units with further

universal joints. Slight over-correction is advisable to allow for distortion due to muscle pull and gravity. The position is subsequently checked by skiagrams, any necessary correction of position usually being easily accomplished without anaesthesia. When there is only room on a fragment for one pin, threaded screws may be employed, but fixation is less secure. When cap splints are also being employed, a bar may be carried from the splint, out of the mouth, to pins inserted at the angle—thus avoiding the necessity for pins in the fragment carrying teeth.

Complications

Sepsis and necrosis

Apart from malposition of the pin due to faulty technique, the main complications are sepsis and necrosis. Sepsis is limited by inserting the pin through a pool of penicillin cream, and by daily cleansing of the pin sites with dilute Dettol, followed by a small ribbon-gauze dressing impregnated with penicillin cream. Necrosis, with the formation of small ring sequestra, has been seen and may be due to heat developed during insertion. Electrolytic action, leading to necrosis and very delayed healing, has been experienced from the use of dissimilar metals, and particularly when the pins have been connected to an intra-oral splint. Electrolysis can be avoided by incorporating a non-conductor (electrical wire insulator) in a universal joint.

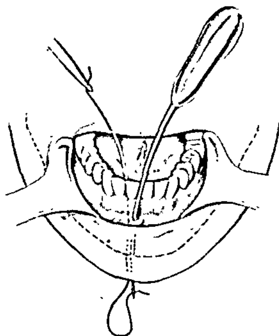


Fig. 19.—A circumferential wire being passed round the mandible by means of an awl. It has been passed on the labial aspect, made to emerge from the same point in the skin, and the wire threaded ready for withdrawal into the mouth.

(4) Circumferential wires

Wires passed round the mandible from within the mouth will control fractures in the body of the mandible, and are employed in three main groups of cases. (a) When the mandible is edentulous, the patient's own lower denture, or a metal trough manipulated to approximate shape and lined with gutta-percha, may be wired to the mandible with two or three circumferential wires (Fig. 19). (b) In children there may be few firm teeth. A cast metal cap splint is prepared and fixed to the mandible with circumferential wires to avoid the strain on the teeth which cementing would entail. (c) The lower border of the mandible may form a separate fragment and be displaced considerably downwards and backwards. A circumferential wire should be used to correct this whenever displacement is severe.

Edentulous mandible

In children

Displaced lower mandibular border

Technique

Circumferential wires are inserted as follows. A curved awl, or long curved needle, is passed close to the mandible from the floor of the mouth and made to emerge from the skin. It is threaded with wire and withdrawn into the mouth. This procedure is repeated on the external surface of the mandible, the awl emerging from the same point on the skin, and the other end of the wire is drawn into the mouth (Fig. 19). By a slight sawing motion the wire can be made to lie against the bone, and it is then twisted tightly round an appliance within the mouth, the end being cut short. Stainless-steel wire, gauge 0·02 inch, is usually employed.

(5) Bone wiring

Fractures of the edentulous mandible

Surgical wiring of bone fragments is the method of choice for fractures of the edentulous mandible in old people when there is gross displacement, especially overlap. In advanced age the mandible becomes dense, brittle and much reduced in size, so that the insertion of pins is not only difficult but hazardous. The technique follows general surgical principles, the inferior border of the bone being subcutaneous.

(6) Alveolar wiring

Fractures of the edentulous maxillae

This principle is employed only when it is necessary to obtain attachment to the edentulous maxillae, as in a dish-face deformity requiring stabilization in a forward position. An acrylic denture base, prepared to a model, is fixed to the upper jaw by wires transfixing the bone from the buccal sulcus to the palate (Walker, 1941). Two or three wires are employed, preferably in front of the antrum, and are best passed through a cannula specially adapted for insertion with a drill. Wire of thicker gauge, 0·03 inch, is less liable to cut out. The fixation of mandibular fragments by wiring the alveolar portion of bone within the mouth is not recommended.

(7) The choice of method

The method of immobilization employed will depend upon the type of injury, the condition of the patient, the facilities available and the preference of the operator.

One or other form of wiring can be adapted to treat the most severe injuries even under primitive conditions. If pin-fixation apparatus is available the scope of treatment is much increased. When immediate operation is indicated for the treatment of other lesions, whether of the facial soft tissues or elsewhere, one of these emergency methods must be employed. If it is likely that cap splints will be required later in treatment, impressions of the teeth may be secured under the same anaesthetic, with due regard to the increase in operation time.

Wiring methods for emergency treatment

Cap splints for delayed treatment

In addition to their value in emergency treatment, wiring methods are excellent for maintaining a good position achieved at an early operation when there are ample teeth in occlusion. Wiring is less suited to methods of slow reduction (*see* p. 41) and far less reliable than cap splints in delayed treatment, when malpositions, adhesions and later complications may be expected.

Cap splints require the full facilities of a dental laboratory and imply a delay of at least 6 hours and frequently more. A perfect technique in all stages is not easy to acquire, for a splint wrongly prepared or applied will perpetuate

malposition. The main advantages are the ability effectively to control a fragment having only one or two teeth, the equal spread of strain over all the teeth and the provision of rigid bar fixation. If correctly designed they are permanent throughout all stages of treatment. Whenever possible cap splints are employed in the treatment of fractured maxillae, the requisite attachments being much more readily applied, and the slight delay is commonly no disadvantage.

Period of immobilization

The period of immobilization will naturally vary with the accuracy of bone approximation, the absence of infection, the age of the patient and other factors. Clinical union is present long before radiographic evidence. In all uncomplicated maxillary and mandibular fractures the degree of union is checked after 4 weeks, when immobilization can be discarded in many cases. Persistent mobility after 6 weeks indicates an unsuspected complication, such as involvement of the root of a tooth or sequestration due to infection. *Complications*

11. INJURIES TO TEETH AND ALVEOLUS

Conservation is the key-word, and a dental opinion should always be obtained. In the first instance only dislocated or completely loose teeth should be removed, because displacement is often greatly increased by attempts to extract a tooth or root from a mobile fragment. If skiagrams show the apex of the tooth to be in a fracture, it should be removed after correct reduction has been effected. Unerupted teeth crossed by fracture lines seldom give trouble and should be left alone unless infection supervenes. Large portions of alveolus, however loose, should always be replaced, the deformity resulting from removal being very severe. *Conservation*

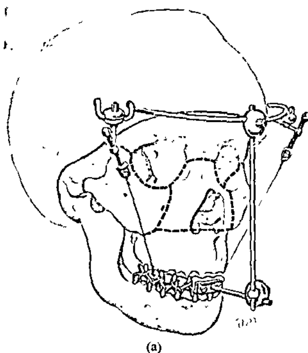
12. FRACTURES OF THE MAXILLAE

(1) Diagnosis

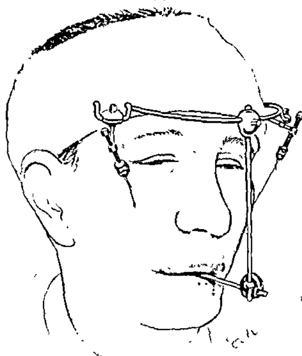
In the early stages after injury the maxillae are usually extremely mobile and diagnosis is easy if the lesion is suspected. Later, when swelling and partial fixation have occurred, great difficulty may be experienced. After the tenth day the bones may be almost firm, and diagnosis must rest upon the presence of mal-occlusion and on consideration of the profile and antero-posterior skiagrams. Since maxillary fractures are most commonly the result of crash or crush injuries, they are often associated with other lesions. *Concomitant fractures*

Sites of fracture

The lesion varies from a partial fracture of the alveolar process to complete separation from the cranium (Le Fort, 1901 and 1941; McIndoe, 1941). The latter may occur at the level of the antral floor (Guerin's fracture), may run higher to include the nose and ethmoid region (mid-face fracture), or may be associated with fracture of one or both zygomatic bones (Fig. 20 (a)). Each variety implies a fracture line across the pterygoid plates in the infratemporal fossa. Dense fibrosis rapidly develops in this area, and 10 days after injury complete reduction of the posterior part of the maxillae is very difficult to achieve. In all complete fractures of the maxillae there is a tendency for the posterior part of the detached fragment, including the teeth, to be displaced downwards, thus gagging the mouth open.



(a)



(b)

Fig. 20.—(a) and (b) *Immobilization of maxillary fractures*—the common sites of fracture, described by Le Fort, are indicated by interrupted lines. Balanced upward traction achieved by wires *from adjustable head-cap* attachments, traversing the cheeks and attached to a cast metal cap splint. A rigid bar passing through the lips maintains level and forward projection. The upper jaw is centred on the mandible by rubber-band traction between *metal cap splints*.

(2) Treatment

The general principle of treatment is to support the maxillary block from a well-fitting plaster head-cap, and to employ the *mandibular teeth as a guide to position*. The best support is provided by wires transfixing the cheeks, from an attachment on the head-cap in the region of the external angular process to the premolar region of a *splint cemented to the teeth* (*Mowlem*, 1941b; Holland, 1945) (Fig. 20 (b)). This vertical lift is more effective than that obtained by extra-oral bars of the Kingsley type, particularly in overcoming depression of the *tuberosity region*.

Splints

Cap splints are prepared for maxillary and mandibular teeth, that for the maxilla having loops in the premolar region; both have numerous hooks for maxillo-mandibular fixation. These are cemented to the teeth.

Edentulous cases

If the maxillae are edentulous, minor degrees of displacement can be ignored. If correction of position is essential, a denture base carrying suitable attachments is constructed to fit the *jaw, to which it is attached by* alveolar wires transfixing the bone from the buccal sulcus to the palate (*see* p. 36). The patient's own denture is readily adapted *for this purpose*.

(*a*) *Head-cap*

A plaster head-cap, constructed of four 3-inch plaster bandages and incorporating metal horns, is applied over one layer of 6-inch tubular stockinet, all the hair being drawn up and back to the vertex, which is not covered with plaster. The plaster should not be brought within 1 inch of the supra-orbital ridges, but should extend down to obtain a hold in the regions of the mastoid processes and external occipital protuberance. The head is not shaved

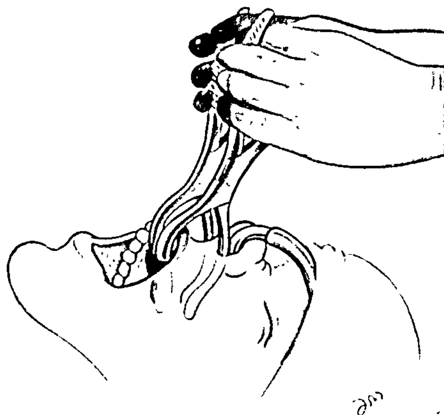


FIG. 21.—Walsham's forceps applied to disimpact and reduce a severe fracture of the maxillary block.

and an anaesthetic is not usually required for application of the splints or the head-cap.

(*b*) *Operation*

For accurate reduction and fixation operation is required. An endotracheal anaesthetic is essential, the nasal route being preferable, although in severe nasal injuries an oral tube must suffice. The pharynx is packed off in the usual manner. The maxillary block is disimpacted and mobilized either by manual pressure or by gripping the mass with various types of forceps (Fig. 21). It is frequently necessary to elevate the zygomatic bones (*see* p. 29) before the maxillary displacement can be corrected. The position is checked by closing *Disimpaction*

the mandible and studying the occlusion of the teeth. When the position is deemed to be correct, a spinal needle is passed through the cheek tissues on either side, in a direct line from the head-cap attachment to the gum margin in the upper premolar region. A stainless-steel wire, 0·02 inch, is passed through this, the needle is withdrawn, and the wire is attached to the splint and the head-cap under tension. When all other treatment has been completed, including nasal reduction, the throat pack is removed and the maxillae are fixed to the mandible with elastic bands applied to the hooks on the splints.

Cheek wires

(c) *After-treatment*

The position of the maxillae requires constant supervision, for a head-cap is an unstable foundation, and marked changes in position may occur in the post-operative period. A true lateral skiagram is an important check on correct reduction. Immobilization is usually required for 4 weeks, although the mandibular fixation can be dispensed with earlier if deviation does not occur after a trial period. It is characteristic of maxillary fractures that firm fibrous union occurs as early as the tenth day, but that a springy movement may persist for as long as 3 months.

Changes in position possible post-operatively

13. FRACTURES OF THE MANDIBLE

(1) Diagnosis

(a) *Body of mandible*

Fractures of the body of the mandible are readily demonstrated by local ecchymosis, laceration of mucous membrane, mobility, changes in the occlusion and by skiagrams.

(b) *Angle of mandible*

Mobility is difficult to elicit unless one finger is placed on the ascending ramus within the mouth, the other hand gripping the anterior fragment. Antero-posterior and lateral oblique skiagrams readily reveal these fractures.

(c) *Subcondylar region*

The most useful sign is swelling in front of the ear with marked local tenderness over the fracture line. Lack of movement of a readily palpated condyle during wide opening of the mouth is evidence of a high ramus fracture, but the opposite is not true, for impaction of the fragments may result in limited movement. The fracture is best visualized by an antero-posterior skiagram.

(d) *Multiple fractures*

Multiple fractures of the mandible frequently occur and must always be anticipated; for example, a fracture of the body of the mandible is often associated with a fracture of the neck of the condyle.

(e) *Displacements*

While the displacement of mandibular fractures is often directly attributable to the injury, it may be much increased by the action of two main groups of muscles. The muscles attached to the genial tubercles have a downward and backward pull which is reinforced by gravity. The muscles of mastication, chiefly the temporal and masseter, are relatively very powerful and cause upward and forward displacement of the angle of the mandible. Fractures between these muscle attachments are common and displacements are therefore exaggerated.

Muscle action important

In fractures of the neck of the condyle due to direct injury, the head is frequently displaced inwards at an angle of as much as 90°, the condition being more correctly a fracture-dislocation. Such severe displacement may cause almost no disability.

(2) Treatment

Consideration of the methods of immobilization available (*see* p. 31) will indicate the line of treatment to be pursued in most types of mandibular fractures.

(*a*) *Body of mandible*

Eyelet wiring is specially suited to the young adult with an almost full complement of teeth in a healthy mouth. Many cases, however, are equally suitable for eyelet wiring or cap splinting. Elastic maxillo-mandibular traction is much used in the method employing cap splints, mild tension so applied as to cause distraction, when associated with talking and swallowing, resulting in perfect reduction of markedly overlapped fractures. The tension is then increased and adjusted to maintain position, or a rigid bar applied with screws (*see* p. 33).

(*b*) *Angle of mandible*

If the fracture is correctly reduced and the anterior fragment is held in occlusion, no further displacement of the posterior fragment will occur in a large proportion of cases. When, however, the fracture line is at such an angle that there is no locking between the fragments, and the muscle pull on the posterior fragment is able to act without restraint, further displacement will occur, union will be delayed, and infection commonly supervenes (Fry and his colleagues, 1942).

In such a case pin fixation is indicated, the anterior fragment being maintained in occlusion by wiring or cap splints in addition, to ensure perfect position.

(*c*) *Ramus and condyle*

Rapid union

Fractures of the ramus are usually well supported by the ensheathing muscles. Fixation may not be required, and union is rapid.

Indications for treatment

The disability suffered following a fracture of the neck of the condyle is very variable. The indications for treatment depend upon the physical signs and not upon the radiographic evidence. When the occlusion of the teeth remains normal, in spite of the fracture, a bandage is applied for 10 days to limit movement; the patient is observed daily. There is always a tendency for the teeth to meet too soon on the affected side, thus gagging the bite. If untreated, this leads to serious dental disability. When it is observed, the occlusion must be corrected and maintained either by wiring under full anaesthesia or by elastic traction employing splints. Fourteen to twenty-one days' fixation is usually sufficient to prevent recurrence. Loss of movement with resultant inability to open the mouth is not serious, and mobility will soon be regained. However displaced, only rarely should the condyle be removed.

(3) Edentulous jaws

Union rapid—infection rare

Fractures of the edentulous mandible are common, but are less frequently compound than when teeth are present. Union tends to be rapid and infection

rarely occurs. In the absence of teeth, perfect accuracy of reduction is not so essential, for the new dentures which are almost inevitably required will permit of minor adjustments of occlusion. If the displacement is minimal, support only is required; preferably, an elastic chin strap is used (*see* p. 31). Whenever there is marked displacement, especially overlap, pin fixation, circumferential wiring or bone wiring is employed (*see* pp. 34–36). Pin fixation is more effective but cannot be employed in very small brittle mandibles nor when there is much comminution.

(4) Fractures of maxillae and mandible

Modern high-speed crashes have increased the incidence of these injuries. The general principles outlined are applied to each case, cap splints being almost certainly required. At operation, the jaw showing least displacement is first corrected and then used to assist in the reduction of the other jaw. The entire facial skeleton is then supported from a plaster head-cap.

Plaster head-cap support

(5) Fractures of the jaws in children

The presence of numerous developing teeth in the jaws and the frequent absence of firm teeth in occlusion make the treatment of these cases more complicated. Green-stick fractures occur but union proceeds rapidly in all cases. If sufficient firm teeth are available, small cap splints are cemented to the teeth, failing which modified splints are held with circumferential wires (*see* p. 35). Developing teeth involved in fracture lines should never be disturbed in the first instance, but if persistent infection indicates that the tooth has become dead it should be extracted. Such a condition seldom interferes with union, which has normally occurred before the extraction has to be undertaken.

Green-stick fractures

14. COMPLICATIONS

Haemorrhage and obstruction

In severe injuries, haemorrhage and obstruction of respiration are early and important complications. An adequate airway must be assured by traction on the base of the tongue and mental portion of the mandible, and by employing the lateral or kidney position.

(1) Infection

Predisposing factors

Infection is a serious and frequent complication of mandibular fractures, but seldom becomes a problem in maxillary injuries. Predisposing factors are delay in fixation and poor oral hygiene. A large fracture haematoma commonly develops, particularly when the inferior dental artery is ruptured, and is readily infected from the mouth. Early immobilization will prevent infection, and with chemotherapy and local heat will allow the haematoma to absorb. This conservative approach should first be tried in almost all cases of incipient infection. When the case is seen late, and there is obvious gross infection, submandibular drainage should be provided at the outset, care being taken that the packing or rubber tissue is not between the bone ends.

Should infection develop after the tenth to fourteenth day, search should be made for a cause, such as imperfect reduction, movement, foreign bodies, or the involvement of the apex of a tooth. Later, evidence of sequestration may become apparent and early operative removal is indicated. Infection almost always leads to delay in union, and is the most frequent cause of non-union.

(2) Anaesthesia

Anaesthesia of the mental branch of the inferior dental nerve is the only other frequent complication. Many patients complain bitterly of the numbness of the lip and of the hyperaesthesia which almost always accompanies recovery. *Hyperaesthesia*

15. TREATMENT OF LATE BONE LESIONS

(1) Nose

Loss of definition of the nasal bridge can result from an unreduced fracture or from destruction of the septum by an infected haematoma. In the latter case the nasal bones are almost inevitably divergent so that the base of the nose is excessively wide. It may be necessary to narrow the foundation upon which the new bony bridge will be placed. A small incision is made just inside the vestibule over the anterior margin of the lower end of the nasal bone and a subperiosteal dissector is passed up to the inner canthus in the line of the frontal process of the maxilla. This process is then divided by a saw, in the coronal axis to avoid damage to the lacrimal apparatus. When the nasal bones are free from their attachment to the maxilla, their upper ends are fractured by digital pressure and they are replaced in position. A small plaster splint is applied for about a week. Three months later the nasal bridge is rebuilt by a bone graft derived from the iliac crest. The exact shape of this graft will depend upon the defect. It is inserted through an incision which either splits the columella vertically or transfixes it at its base to expose the potential space between the two layers of the septum. Sufficient suitable bone is not available much before the age of 14 (Mowlem, 1941a). *Plaster splint applied*

(2) Fractures of frontal or zygomatic bones

Old unreduced fractures of the frontal or zygomatic bones can seldom be repaired by mobilization of the original bone. They can, however, be disguised by building up the requisite contour with cancellous chips from the iliac crest. Access is usually obtained through a local scar or any suitable skin crease. The underlying bone is exposed and built up with bone chips so arranged that they present a smooth surface layer. Their position is maintained by pressure bandage for from 4 to 5 days. *Losses of contour*

(3) Mandibular loss or mal-union

When there is an actual bone defect or an established line of non-union in the jaw, there is no justification for deferring bone grafting for longer than is necessary to ensure the elimination of any residual sepsis. The co-operation of a dental surgeon will be essential to provide the requisite fixation, the type of which will vary from cap splints on both halves of the mandible when there are teeth on each fragment, to more complicated intra-oral or extra-oral fixations. The basic principle, however, remains the same. The position of the larger fragment is determined by locking it to the maxilla, and the position of the smaller fragment is corrected in relationship to the larger by whatever type of fixation is effective. It is undesirable that the fixation should be locked during the early stages of the operation as it may be dislodged during the process of dissection. An incision about ½ inch below the mandibular line is deepened to expose the bone ends. These are carefully *Bone graft technique*

freed from their attachment to the oral mucosa. At this point there is considerable danger of opening the mouth, but unless this dissection is complete replacement of the posterior fragment in its correct position is often impossible. The eburnated bone ends are cut away obliquely to create a wide vascular area. The fragments are fixed by the dental appliances and a thin strip of cancellous bone is tucked beneath the freshened bone ends to prevent the soft tissues of the floor of the mouth from bulging into the defect and to protect the overlying chips against movement. Bone chips, resting on this bony bridge and on the mandibular ends, are used to restore bulk and contour. They are held in position only by suturing the subcutaneous tissue and the skin in separate layers over them. All bone used in this type of grafting is derived from the iliac crest and consists mainly of cancellous tissue. If the oral mucosa has been opened it should be carefully closed and a capillary tube inserted down to the wound so that a minimum of 1,000 units of penicillin can be instilled twice a day for 4 days. Fixation between the bone ends is retained for about 30 days (Mowlem, 1944).

Chemotherapy

The reconstruction of the mandible may well result in bone continuity without restoration of the buccal sulcus. This may make the subsequent fitting of dentures impossible, and it is desirable while teeth are present to re-create the sulcus to allow future dental competence.

Reconstruction of buccal sulcus

Cap splints are fitted to the remaining teeth in the jaw, carrying a plate which overlies the area involved. At operation the soft tissues of the cheek are dissected off the bone, care being taken not to expose it. A mould of dental impression compound or gutta-percha is fashioned to fit the raw area and is retained in position by the plate. The mould is used as a vehicle to carry a very thin skin graft cut from a relatively hairless area. After about 14 days the mould can be removed for cleansing purposes and thereafter it can be taken out daily. For from 3 to 9 months there is a very great tendency for these grafts to contract. During this period the mould must never be out of position for more than a very few minutes.

(4) Late lesions involving the temporo-mandibular joint

Inability to open the mouth does not usually follow maxillo-mandibular fixation even when this is maintained for a long period.

Trismus may occur from two causes.

(a) Internal disorganization of the joint by injury, infection or arthritic change.

(b) Fibrosis of extra-articular soft tissues caused by trauma or sepsis.

Internal disorganization can usually be revealed by careful skiagrams. Surgery is not indicated unless there is so much disorganization as to limit movement to an extent which precludes mastication or to occasion so much pain as to render the patient's life miserable. Surgical reconstruction of the joint is not, so far, satisfactory and, if intervention is justified, resection of the affected condyle is, at the moment, the best method of treatment.

Access can be gained by an incision in either the pre-auricular or the post-auricular regions. The former must lie very close to the ear in order to avoid the upper branches of the seventh nerve, whereas the latter necessitates a division of the external auditory meatus. Dissection is continued downward to expose the neck of the condyle which is divided either by a Gigli saw or, more

easily, by an osteotome. The head is dislocated from its capsule and freed from its attachment to the external pterygoid. This latter muscle always presents some difficulty. A sufficient amount of bone is removed to avoid any possibility of subsequent ankylosis—at least ¼ inch of the neck of the condyle. It may also be necessary to divide the coronoid process, to ensure a free range of movement. Dental fixation may be required, for a period of from 2 to 4 weeks, in order to maintain the correct bite.

The extra-articular causes of trismus can be determined by clinical examination together with radiographic exclusion of the presence of intra-articular damage. The condition may be improved by subperiosteal dissection of all the muscular attachments to the buccal and lingual aspects of the ascending ramus. The mandible is then splinted in the open position until the shortened muscles have become re-adherent at a higher level.

In both intra-articular and extra-articular lesions it must be remembered that the prolonged fixation of the jaw in the closed position will probably have resulted in secondary shortening of the muscles and capsule on the sound side and re-education may therefore be necessary.

PART II

DEFORMITIES

1. CONGENITAL LESIONS

(1) Vascular naevi

Capillary naevus

(a) Capillary naevus, which causes discoloration of the skin varying from a faint pink flush to a deep port-wine stain. The texture and level of the skin tend to be normal.

Mixed capillary and cavernous naevus

(b) Mixed capillary and cavernous type, in which the surface of the affected area is red and is raised above the surrounding skin level. Compression easily flattens the surfaces and causes some blanching and there is slow recovery of colour and shape upon release.

Cavernous naevus

(c) Cavernous naevus. The overlying skin may well be normal but the affected area is raised above the surface, is frequently warmer than the surrounding areas, is capable of compression and sometimes has a bruit which is either palpable or audible.

(*a*) *Pathology*

The capillary type consists of a network of well-differentiated capillaries confined in most instances to the skin.

In the mixed types the skin capillaries may retain their structure, whilst in the deeper layers the vessels are merely irregular spaces lined by endothelium.

The cavernous type usually consists solely of intercommunicating spaces, the lining of which is ultimately continuous with one or more large vessels.

(*b*) *Differential diagnosis*

The first two types present no difficulty but the third must be differentiated from localized abnormalities of the lymphatic system which are not hotter than the surrounding area and which have no palpable or audible bruit.

(c) Treatment

Treatment is largely dependent upon the degree of differentiation of the vessels which comprise the lesion. The more these vessels approximate to the normal the less easily they respond to treatment.

Scarring agents contra-indicated

The use of scarring agents such as carbon dioxide snow, electrolysis or diathermy, can result only in the destruction of all structures both abnormal and normal and their replacement by a cicatrix. In small lesions this may be unimportant, but in larger ones the replacement of normal but discoloured skin by white and irregular scar will effectively preclude the use of cosmetics to hide the deformity.

Only some method of treatment which has a specific effect upon the vessels or the possibility of total removal of the area and replacement by good skin justifies interference.

Repair by flaps or free grafts

(i) *Capillary type.*—These naevi are but seldom sensitive to x-ray or radium therapy although thorium may prove beneficial. If they respond at all they do so most readily in the first year of life. If they are not radio-sensitive it is best to defer operation until it is clear that spontaneous cure will not occur. Excision and repair, either by flaps or by free grafts, produces good results.

(ii) *Mixed type.*—These are more readily treated by irradiation to which their sensitivity is greatest in the first few months of life. They may undergo spontaneous cure and are much more prone to do so than is the capillary type of naevus. They will disappear if intravascular clotting can be induced by any means. This frequently happens in childhood, as a result either of minor overlying skin infections or of injuries. They are therefore seldom seen in adults.

(iii) *True cavernous naevus.*—Such naevi are not subject to spontaneous cure and are probably best treated either by interstitial radium or by injection of a sclerosing fluid. Occasionally response to this type of treatment is not obtained and ligation of all the vessels supplying the area appears to be the only alternative. This is always an extremely bloody and difficult operation, and should be deferred until the patient is old enough to be co-operative and to withstand it. When the naevus has been obliterated, cosmetic defects often remain; these can be dealt with at a later date.

(2) Pigmented naevi

This is a general term applicable to many conditions varying from small moles to disturbances of pigment or hair involving large areas.

(a) Pathology

In almost all cases there is an undue deposition of pigment cells in the deeper layers of the skin. Overgrowth of hair follicles and sebaceous glands is common, and in later life the depth of the keratotic layer of the skin may be considerably increased.

There is said to be a tendency for such areas to become melanomatous but it should be remembered that the number of people who present some abnormality of pigment distribution must approximate to 100 per cent. In spite of this the incidence of malignant melanotic change is extremely low.

Malignant melanotic change rare

(b) Treatment

Moles are best dealt with by excision and suture. The resultant scar should be linear and practically invisible and should compare favourably with the

circular depressed scar produced on destruction by electrolysis or carbon dioxide snow.

The more extensive lesions are at first slightly pigmented. With increasing age they become much darker, acquire a marked growth of hair and finally show considerable heaping up and irregularity of the surface due to hyper- *Hyperkerato* keratosis. In this stage they are said to be prone to undergo malignant changes and it may, therefore, be desirable to consider removing them relatively early.

Naevi, not exceeding in area about 2 square inches, can often be treated by serial excision, that is, by removal of an oval from the centre of the mole with approximation of the margins. This will result in some tension in the surrounding skin but, over a period of months, this decreases to such an extent that finally the entire mole can be removed and the normal skin edges approximated without tension.

The applicability of this method is determined by the situation. Round the eyes, nose and mouth it will seldom be useful and in these sites tissue will need to be imported, either from adjacent or from distant areas. Sometimes a free graft will be adequate and in or round the eyelids this may be the method of choice.

2. ABNORMALITIES OF EARS: CONGENITAL

Many abnormalities of the ear and the external auditory meatus are related *Aetiology* to failures of normal development in the first branchial cleft, though others appear not to have any such clearly defined causes.

(1) Bat ears

These are characterized by undue prominence and by partial loss of the normal folds of the auricle. The condition does not respond to any of the means of correction which mothers are prone to apply in the first few months of life. It may be desirable, particularly in boys, to reduce the degree of prominence by crescentic excision of part of the post-auricular skin and part of the ear cartilage. After operation the ears are firmly bandaged for one week and thereafter it is desirable to protect them—particularly at night, against any forward drag, such as might be occasioned by turning the head on the pillow—by a light bandage for a further week.

(2) Complete or partial absence of the ear

This condition may be associated with an imperforate auditory meatus. Operation for this must depend upon the presence of a normal inner ear.

The more extensive lesions of the pinna are usually associated with agenesis of the ascending ramus of the mandible and with asymmetry of the face.

In girls developmental failure of the auricle does not present any very serious problem but in boys it may be desirable either to reconstruct the ear or to provide a prosthesis to disguise the disability. Reconstruction may be *Prosthesis* carried out by utilizing either maternal ear cartilage or rib cartilage as a basis. (Gillies, 1937.) Alternatively stored sterilized animal cartilage may be used.

The technical difficulties of creating anything which closely resembles an ear are very great and it may be better to concentrate on making it possible for the patient to wear a prosthesis. One of the simplest methods of fixation of the

appliance is the construction of one or two very short horizontal pedicles in the mastoid skin which provide loops on to which the ear can be hung so that reliance is not placed entirely upon the use of gum. (Round, 1943.)

(3) Auricular remnants

Possible ramifications

These are extremely common and may vary from a small skin nodule immediately in front of the external auditory meatus to a sinus commencing in the same region and extending down usually to the region of the supra-tonsillar fossa (*see* Ear, Maldevelopments of, Vol. 3, p. 303). There may be ramifications from this sinus opening in the side of the neck immediately behind the angle of the jaw and the complete dissection of this condition is by no means simple.

3. ORBITAL REGION: CONGENITAL LESIONS

(1) Coloboma of the lids

This is a relatively rare condition, sometimes associated with lesions of the globe itself but often occurring without such complications. It consists in a defect of a variable amount of the full-thickness of the lid in almost its complete vertical extent. As a general rule it can be made good by paring the margins of the defect and by advancing the lateral part of the lid medially. Accuracy of suture is essential and care must be taken not to divide the nerve supply to the orbicularis at its point of entry into the muscle.

(2) Symblepharon

Symblepharon also is a relatively rare condition which often responds to simple division followed by epithelialization of the margins of the defect by approximating the conjunctiva to the skin, but which may require grafting. (Gillies and Kilner, 1929.)

(3) Epicanthus

Association with ptosis

This condition is characterized by a vertical fold of skin overlying the inner canthus and fusing with the soft tissues of the cheek below and the upper lid above. It is very frequently associated with a greater or lesser degree of ptosis and may perhaps contribute mechanically to the presence of that condition.

"Z" plasty

When the fold is very marked there is usually sufficient skin to allow complete rearrangement by means of a " Z " plasty (*see* p. 25).

Post-auricular Wolfe graft

If there is insufficient skin for this purpose it is wise to utilize all the skin in the fold for the reconstruction of the upper lid and make good any final defect in the inner half of the lower lid by a post-auricular Wolfe graft. If this operation is carried out at about the age of four the ptosis may, within the next year or two, show signs of improvement but if, after a sufficient lapse of time, this is not the case operation for the correction of this condition is indicated.

(*See* Eyelids, Vol. 3, p. 509)

4. ORBITAL REGION: ACQUIRED LESIONS

Contracted eye sockets

The removal of a damaged eye may leave a conjunctival socket which is insufficiently capacious to retain a prosthesis. Occasionally after a prosthesis has been worn for many years the socket undergoes spontaneous contracture,

the exact cause of which is not clear. In either case the socket can be reconstructed by a complete dissection of the whole of the remnants of conjunctiva from the inner aspects of the lids and from the socket itself. A sufficiently capacious opening will automatically be created and into this is fitted an almost spherical mould of gutta-percha carrying a thin hairless skin graft. Care must be taken to ensure that the lids will close easily over this mould and also that the mould is big enough to provide normal prominence of the lids. It is undesirable to remove the mould for from 3 to 4 months, that is, until the stage of contracture of the graft is passed. At the same time it will be found that many moulds tend to extrude very rapidly. Suture of the lids will, as a rule, be ineffective and the mould can be held in position only by a fixed appliance supported by a light skull-cap or by a splint on the upper teeth.

Reconstruction by dissection

Mould of gutta percha

5. NOSE: CONGENITAL DEFECTS

(1) Dermoid cysts

These may occur in two regions, one in the septum and the other in the glabellar region. The former very often shows an opening in the midline of the nose, which in later life grows hair and may be responsible for a certain amount of discharge, and the latter is sometimes associated with an underlying defect in the skull which may communicate with the meninges. In both instances careful complete excision is indicated.

In septum or glabellar region

(2) Bifid nose

This is characterized by excessive broadening of the bridge of the nose and lack of all definition of the nasal bridge line. The nasal bones are found to be widely divergent and the septum to be in the form of a Y. The amount of septum so involved can vary from a small area in the region of the lateral cartilages to the entire septum. In extreme cases there is marked widening and irregularity of the naso-ethmoid region with hypertelorism. At best this deformity can only be diminished.

6. CLEFT LIP AND PALATE

(1) Development

The upper lip is developed from three elements. Its central part is derived from the median nasal process and its lateral parts come from the maxillary processes. Fusion between these elements commences in the floor of the nostril and extends downwards to the free margin of the lip.

Derivation from three elements

Complete or partial failure of fusion can occur. In the former instance the prolabial skin will be completely free from its attachments to the remainder of the lip; in the latter case any degree of deformity can be encountered but partial failures will affect the free margin of the lip and not the vestibule.

The palate is also derived from three sources. The median nasal process produces the premaxilla and the palatal processes of the maxillary processes form the remainder of the hard and the soft palate. The fusion line between these two elements is Y-shaped with the stem of the Y lying posteriorly. Union commences in front and extends backwards so that, once started, premature cessation will produce a posterior defect.

Within the limitations caused by the directions in which fusion occurs any degree of cleft of the lip or palate can be encountered. The activating cause is unknown, though in animals there is evidence to suggest that dietetic deficiency may be important.

Activating cause unknown

(2) Clinical picture

Deformity of alar cartilage

The cleft lip, no matter what its degree, is associated with some deformity of the alar cartilage on the affected side. The medial crus is lower and lies farther back than its fellow. The alar base is similarly displaced and when the cleft is extensive there is often associated under-development in the maxilla at its anterior margin as well as disorganization of all the elements of the nose. When the palate is cleft the nose and mouth are to a greater or lesser extent one cavity. The normal valvular action of the soft palate is lost and difficulties in feeding and speech will arise.

(3) Prognosis

Lesions confined to the lip produce only cosmetic disability and their repair is not of immediate urgency. When the palate is cleft, though the initial difficulties in feeding can be overcome the nasal mucosa will ultimately become hypertrophic and there is every probability of associated sinus and ear infections. Speech will be abnormal.

Associated sinus and ear infections

(4) Indications for surgical intervention

If the lip only is affected there is no urgency in undertaking its repair. When the palate is involved authorities vary as to the optimal time of operation. Some defer it until the third year or later. Technical difficulties are thereby decreased but, on the other hand, the likelihood of nasal infection is increased and post-operative speech training becomes essential. Other surgeons prefer to operate before the palate is used for speech purposes, that is, within the first 3–9 months. Technical difficulties are outweighed by the advantages of the early creation of a mechanism which closely approximates to the normal. Feeding difficulties are avoided, the likelihood of nasal infection is diminished and the necessity of speech training is reduced.

(5) Pre-operative management

Precautions regarding nasopharyngeal infection

If operation is deferred, no dietetic preparations are necessary but the elimination of any foci of nasopharyngeal infection is desirable.

If operation is to be undertaken early, the child is trained to spoon feeding, and is kept on a normal diet until its weight reaches 10 pounds or more. Should this occur when nasopharyngeal infections are epidemic it may be justifiable to wait for a further month or two.

Although, in small infants, the technical difficulties of the operative and post-operative stages are very great, the advantages of the early production of functional normality are enormous.

(6) Operative technique : general

(*a*) *Aim of operation*

In the case of a simple cleft lip the aim of the initial operation is to create continuity of the orbicularis oris, to reconstruct the floor of the nasal vestibule so that it is of the correct width and height, and to restore the alar base

on the affected side to its normal position. It may be unwise to attempt too much in the way of correction of the deformities of the medial crus because, once the cleft lip is closed, the pre-existing deviation of the septum tends to correct itself and this modifies the position of both medial crura.

When the palate is cleft the aim of operation is not merely the production of lateral closure of the defect in both the hard and soft palates but the creation of an intact and mobile soft palate of sufficient length to enable it to be approximated to the posterior nasopharyngeal wall with ease and efficiency. In the unoperated state the antero-posterior length of the palate is often such that the uvular elements do not lie anywhere near such a position. The problem, therefore, is not only the approximation of the remnants in the midline but also their elongation.

(*b*) *Anaesthesia*

Nitrous oxide, oxygen and ether is usually the anaesthetic of choice. It is given through an endotracheal tube passed through the mouth and, as an additional protection against the inhalation of blood and saliva, the pharynx is packed with gauze soaked in saline or liquid paraffin. When a gag is used the tube lies beneath the tongue piece.

(*c*) *Technique*

So many varying degrees of palatal and lip clefts are encountered that it may be simpler to describe separately the repair of a cleft lip and the repair of the simplest form of cleft palate, that is, the involvement of the soft palate only. By so doing the two main problems will be considered—appearance in the case of the lip and function in the case of the palate. When the cleft is complete and involves the lip, the hard palate and the soft palate, it will be appreciated that the central area, that is, the hard palate, is repaired first so that it forms the foundation upon which appearance and function can subsequently be built.

(i) *Repair of simple cleft lip.*—The incisions are planned to commence in the nasal vestibule so that sufficient tissue is removed to reduce the floor of the vestibule to its correct width. They continue down through all thicknesses of the lip to the muco-cutaneous margin where they turn a little towards each other to leave a slight excess of mucous membrane on each half of the lip. The position of the point of turn is such that the length of the incision from the nasal vestibule to the muco-cutaneous margin is equal to the vertical distance between two similar points on the normal side of the lip. The raw surface of lip so created is divided into its three components, skin, muscle and mucous membrane. Finally an incision is made in the line of reflection of the mucosa in the buccal sulci on both sides, and the lip dissected free from its attachment to the superior maxilla on one side and the premaxilla on the other. In the former region the dissection may need to be very extensive, and sometimes continues into the bony nasal cavity to allow the alar base to be moved forward and medially without tension.

The three layers of the lip are repaired by commencing with a few catgut stitches in the mucosa in the upper part of the buccal sulcus. Next the orbicularis is approximated and particular attention is paid to its upper margin in order to support the alar base in a normal position. The skin is closed with very small sutures of fine silk, and finally the small flaps of mucosa in the lip

margin are interdigitated to provide the normal fullness of the edge of the lip (Fig. 22).

Repair of soft palate alone

(ii) *Repair of cleft of soft palate.*—The simplest type of palatal cleft involves the soft palate only. It is repaired by paring the margins of the defect to

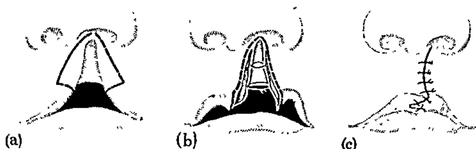


FIG. 22.—Three stages in the repair of a simple cleft lip: (a) incision; (b) isolation of the three component layers and commencement of the mucosal suture; (c) completed skin closure after approximation of the muscle and the interdigitation of the mucous-membrane flaps.

expose the three constituent layers. These incisions are then continued forwards and laterally on to the hard palate until they reach the inner aspect of the alveolar margin. They then return parallel and close to the alveolar margin and continue beyond the tuberosity to lie over the palpable hamular processes. The entire thickness of the muco-periosteum, over the hard palate within these incisions, is raised and will expose the posterior margin of

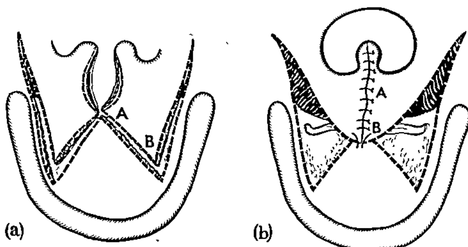


FIG. 23.—(a) Diagram illustrates the incision lines for pairing of the margins of the palatal defect and for elevation of the muco-periosteal flaps. (b) The defect sutured. The nasal lining has been closed first, and the flaps rotated medially and backwards to elongate the palate. Note the new positions of the points A and B.

the bony hard palate and the posterior palatine vessels. These vessels are isolated by careful dissection, which then continues backwards to expose and fracture the hook of the hamulus and finally upwards on the medial aspect of the internal pterygoid plate. The mucosa of the floor of the nose is detached from the bony hard palate by careful dissection on its upper surface. The palate is now attached only posteriorly and by the posterior

palatine vessels. The nasal floor is reconstructed by interrupted sutures of catgut (6 0) so inserted that their knots lie in the nasal cavity. The process of suture continues round the uvula and comes to lie on the oral surface of the palate. It is continued forwards to include almost all of the medial margins of the muco-periosteal flaps which were raised from the bony hard palate. In other words, part of the original oblique lateral incision is now included in the midline repair so that the palate has, in effect, been rotated medially and backwards. Finally to anchor the repair in position the anterior ends of the sutured flaps are stitched to the previously untouched V of hard palate. This operation is known as the VY advancement operation (Veau, 1931) (Fig. 23). *VY advancement operation*

At the discretion of the operator, the lateral defects may be packed with gauze wrung out in paraffin-flavine or Whitehead's varnish, or may be left to

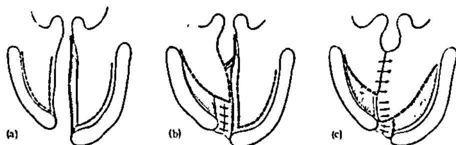


FIG. 24.—(a) The incision for the septal and muco-periosteal flaps; (b) the elevated septal flap has been sutured to the nasal mucosa and one muco-periosteal flap has been swung towards the midline; (c) the muco-periosteal flaps have been sutured together and anchored to the previously repaired nasal flap; the lateral defects at the base will close by secondary epithelialization.

granulate. It is wise in all operations upon the palate to control the tongue in the immediate post-operative phase by a heavy silk stitch passed through its tip *Control of tongue*

This operation is the most important stage of the repair no matter what degree of cleft is originally present. If the cleft involves the hard palate it may be necessary to close the anterior part at a separate and prior operation so that a foundation can be created upon which an effective valvular mechanism can be constructed.

(7) Treatment of a complete cleft of lip and palate

(a) *Unilateral*

A self-retaining gag, preferably of the Shadwell pattern, is inserted and a flap of muco-periochondrium is raised from the side of the septum as far back as the posterior margin of the hard palate (Fig. 24). On the opposite side a muco-periosteal flap based on the posterior palatine artery is elevated and the mucosa of the floor of the nose on this side is raised to enable it to be approximated with ease to the septal flap. The anterior ends of both these incisions will be found to lie in the cleft in the alveolus and later become continuous with the dissection to be carried out on the lip. The floor of the nose is reconstructed with interrupted catgut stitches, at least two of which are inserted in such a fashion that their free ends can subsequently be used to *Cleft palate*

anchor the muco-periosteal flaps on the palatal aspect, so that both layers of the palate are maintained in approximation (Fig. 24). If the palatal muco-periosteal flap from one side is found to be insufficient, a similar one can be raised on the opposite side and swung medially to meet its fellow (Veau, 1931). The mouth gag is then removed and it will be found that the repair of the nasal floor already effected has resulted in approximation of the mucosal flaps which must be used to reconstruct the floor of the vestibule.

Cleft lip

The margins of the cleft in the lip are pared, leaving the resultant flaps attached to the mucous membrane. The lip is divided into its constituents and is freed from its attachment to the maxilla on one side and to the premaxilla on the other side, sufficiently to enable it to be approximated without tension. This may entail a very extensive dissection on the side of the cleft.

Three-layer approximation

The lip elements are approximated in three layers, paying particular attention to apposition of the soft tissues at the alar base with the tissues at the base of the septum. It is advisable also to leave as much mucosa as possible in the free margin of the lip to avoid the inrolled appearance of the lip so frequently seen after a primary repair.

(*b*) *Bilateral*

This can be dealt with by a procedure very similar to that described above, and if the condition of the child does not warrant the completion of both sides simultaneously it is advisable to deal with one side and defer the treatment of the other for a period of from 2 to 3 weeks. In the bilateral cases it is usually essential to incorporate the prolabium in the lip during the initial repair. There is seldom sufficient material in the lateral elements of the lip to enable them to be approximated in the midline without undue tension because of forward rotation of the premaxilla. When the continuity of the orbicularis oris has been established, this rotation is gradually corrected and at a later date secondary operations can be undertaken to improve the cosmetic result.

Correction of rotation

At the end of the first operation on either the complete unilateral or the complete bilateral cleft palate it will be seen that the soft palate remains untouched. The condition has, therefore, been converted into a state very similar to that described under the heading of Technique in the operation for cleft of the soft palate only, and its surgical treatment will be the same. The interval between the primary operation and the definitive final operation is approximately 3 months. The reason for this delay is to ensure that the anterior flaps acquire a sufficient blood supply in their new position to enable them to be deprived of any input from the posterior palatine vessels without risk.

Variants of basic operations

Variants of these basic operations will obviously be applicable to lesser degrees of cleft. In some instances, as for example a bilateral cleft of the palate not involving the alveolus, it may be possible to combine the two stages in the same operation, but whenever there is any doubt as to the possibility of obtaining sufficient length in the palate it is probably preferable to do a two-stage repair.

(8) Post-operative management

The tongue stitch referred to above is retained until the child is completely conscious and it is clear that there is a competent airway. Some children

have difficulty in adjusting themselves to breathing either through the mouth or through the nose alone instead of through the pre-existing common opening and in these cases the suture can be retained for as long as 24 hours.

Over-heating to be avoided

Chloral or Nepenthe for sedation

In the immediate post-operative phase over-heating must be guarded against. Sedatives are seldom necessary but when they are indicated small doses of chloral or Nepenthe are sufficient. Feeding can be recommenced within a few hours of operation. It is desirable to dilute the first post-operative feed to half strength with 10 per cent glucose. With very small babies no particular attention to the operative area is possible but the use of a few spoonfuls of water after a milk meal tends to prevent the adhesion of curds to the suture line. With older children active swabbing may sometimes be necessary but is seldom desirable.

Initial temperature rise

There will frequently be a rise of temperature to about 100°–100·5° F. for the first two days after operation. This may be aggravated by complete nasal obstruction, which is particularly prone to occur if the operation has resulted in a very long palate. The child's comfort can be increased by aspiration of the nasopharynx above the palate, using a soft rubber catheter passed into the nostril. If a pack has been placed in the lateral defect it is removed on or about the seventh day and within a further 3–4 days the mouth is usually healed.

(9) Secondary operations

(*a*) *Lip*

Such operations will be designed to improve the appearance of the lip and nose and may be deferred until the third or fourth year or even much later. Reorganization of the nasal tip with correction of the position of the medial crura will present many difficulties. In cases of bilateral cleft there is a tendency for the length of the nose to be small in relation to the vertical depth of the lip and many operations have been devised to correct this.

Unilateral cleft lip

In the case of a unilateral cleft lip it will probably be necessary to correct the residual deformities of the ala on the affected side and to re-create the normal Cupid's-bow line of the muco-cutaneous margin. It is seldom justifiable at the primary operation to make any serious endeavour to eliminate all the nasal deformities, for two reasons. The first is that the operation is thereby unduly lengthened and the second is that, prior to the restoration of continuity of the orbicularis, the nasal septum and the nasal tip will have drifted to the side away from the cleft and with the restoration of continuity of the muscle this will in part be corrected. Correction of those soft tissues supported by a skeleton which will later come to occupy a new position is therefore a waste of time.

Bilateral cleft lip

In the case of a bilateral repair the operation will consist in the complete excision of all the scar in the lip, extensive freeing of the prolabial skin and its advancement up into the columella with approximation of the lateral elements of the lip in the midline (Veau, 1931).

(*b*) *Palate*

If the operations described above have been successful, secondary operations should be unnecessary. The operator may, however, be confronted with many surgical shortcomings.

Complete breakdown

Complete breakdown is almost invariably due to *insufficiently extensive* dissection with resultant tension. It should not cause any tissue loss and the operation may be repeated when fibrosis has absorbed, that is, in from 6 to 9 months. Partial breakdown is most often confined to the hard palate and is due to lack of blood supply or inaccurate apposition of the anterior ends of the flaps. After some delay closure can often be carried out by local flaps but it should be remembered that dentition is often irregular in cases of cleft palate and that the wearing of a denture may ultimately be desirable. This same denture may also be used to cover defects in the hard palate.

Partial breakdown

Short immobile soft palate

A short immobile soft palate mayalso be encountered. A valvular effect may be produced by bringing the posterior pharyngeal wall forward to enable even a short palate to reach it by the method described as pharyngoplasty (Wardill, 1937) or alternatively by some operation which displaces the short palate farther back.

Of such operations there are many; Gillies and Fry, 1921; Dorrance, 1925; Dorrance and Bransfield, 1943; and others, have endeavoured to solve the problem but each case must necessarily be judged upon its merits.

BIBLIOGRAPHY AND REFERENCES

Buxton, J. L. D., Parfitt, G. J., MacGregor, A. (1941). *Brit. dent. J.*, **71**, 295.
Dorrance, G. M. (1925). *Ann. Surg.*, **82**, 208.
— and Bransfield, J. W. (1943). *Ann. Surg.*, **117**, 1.
Fickling, B. W. (1946). *Brit. dent. J.*, **80**, 8.
Fry, W. K., Shepherd, P. R., McLeod, A. C., and Parfitt, G. J. (1942). *The Dental Treatment of Maxillo-Facial Injuries.* Oxford; Blackwell.
Gillies, H. D. (1935). *Brit. dent. J.*, **59**, 361, 405.
— (1937). *Revue de Chirurgie Structive*, No. 3. Brussels.
— (1939). *Amer. J. Surg.*, **43**, 201.
— and Fry, W. K. (1921). *Brit. med. J.*, **1**, 335.
— and Kilner, T. P., (1929). *Trans. ophthal. Soc. U.K.*, **49**, 470.
— — and Stone, D. (1927). *Brit. J. Surg.*, **14**, 651.
Holland, N. W. A. (1945). *Brit. dent. J.*, **79**, 333.
James, W. W., and Fickling, B. W. (1940). *Injuries of the Jaws and Face.* London; Bale and Staples.
Le Fort, R. (1901). *Rev. Chir., Paris*, **23**, 208.
— (1941). *Brit. dent. J.*, **71**, 1.
MacGregor, A. B. (1945). *Lancet*, **1**, 816.
McIndoe, A. H. (1941). *Brit. dent. J.*, **71**, 235.
McLeod, A. C. R., and Shepherd, P. R. (1941). *Brit. dent. J.*, **71**, 267.
Mowlem, R. (1941a). *Brit. J. Surg.*, **29**, 182.
— (1941b). *Brit. dent. J.*, **71**, 323.
— (1944). *Lancet*, **2**, 746.
Padgett, E. C. (1944). *American Academy of Orthopaedic Surgeons presents Lectures on Reconstruction Surgery*, ed. by Thomson, J. E. M., pp. 216–224. *Ann. Arbor.*
— (1946). *Amer. J. Surg.*, **72**, 683.
Round, H. (1943). *Proc. R. Soc. Med.*, 36, 9, 486.
Veau, V. (1931). *Division Palatine Anatomie, Chirurgie, Phonetique.* Paris; Masson.
Walker, D. G. (1941). *Brit. dent. J.*, **71**, 173.
Wardill, W. E. M. (1937). *Brit. J. Surg.*, **25**, 117.
[References to other titles are given under Facio-Maxillary Injuries and Deformities in the Index Volume.]

FALLOPIAN TUBES

By W. C. W. NIXON, M.D., F.R.C.S., F.R.C.O.G.
Professor of Obstetrics and Gynaecology, University of London;
Director, Obstetrical Unit, University College Hospital, London

PART I
SALPINGITIS

PAGE

PART II
CHRONIC SALPINGITIS

PART III
ECTOPIC GESTATION

149.] *The most common conditions requiring operative* treatment are salpingitis and ectopic gestation.

PART I

SALPINGITIS

1. DEFINITION AND AETIOLOGY

Salpingitis is an inflammatory process involving the Fallopian tubes. *It can* occur at any age but usually does so in women in the younger age group.

Primarily, the infection may follow abortion, labour or gonorrhoea. Vaginal douching or intra-uterine manipulations with a view to inducing abortion may cause an ascending infection which will involve the tubes.

Secondarily, the disease may result from extension from an inflammatory focus already present within the abdominal cavity, such as appendicitis.

2. PATHOLOGY

Organisms

In about 50 per cent of cases the offending organism is the gonococcus. In such the infection is an ascending one starting from the cervix.

In puerperal cases the organism is either of the staphylococcal or streptococcal group. The *infection can spread from the uterine cavity* or by lymphatics. After the menopause, *Bacillus coli communis* is most commonly found. Tuberculosis and infection by the pneumococcus are rare.

When the organism is staphylococcal or streptococcal the infection may remain dormant for years. With gonorrhoea, cultures from the tubes are usually sterile after 3 months.

(1) Catarrhal salpingitis

Types

This is the mildest type and may pass unnoticed. The mucosa *of the tube* is mainly involved. When the inflammation becomes more severe the wall of the

tube is invaded so that it becomes nodular, kinked and the fimbriae adherent. With closure of the abdominal ostium the tube distends and later a hydrosalpinx develops.

(2) Suppurative salpingitis

In this there is an excessive purulent exudate and other pelvic viscera become involved.

(3) Pyosalpinx

The tube is sac-like and distended with pus. The abdominal ostium is closed. It is usually adherent to other structures. Sometimes it is impossible to distinguish the ovary owing to its involvement (tubo-ovarian abscess).

3. CLINICAL PICTURE

A patient suffering from acute salpingitis presents the picture of pelvic peritonitis. There may be a history of vaginal discharge, intra-uterine manipulations, recent abortion or delivery. Lower abdominal pain is complained of, which is aggravated by exercise. Fever is present and may be high, especially in post-abortion or post-partum cases. Neither vomiting nor nausea is usually a prominent feature but headache may be severe. The leucocyte count and blood sedimentation rate will be increased. *History*

On abdominal examination there will be hypogastric tenderness especially marked to one or other side of the midline. The concomitant rigidity which extends across the lower part of the abdomen makes examination difficult. Tenderness is sometimes greater in the left than in the right iliac fossa. Movement of the hypogastrium is restricted on respiration. *Abdominal examination*

On pelvic examination discharge may be seen at the introitus. Bimanual palpation will cause pain over the fundus of the uterus and when one or other tube is palpated through the fornix. The vagina feels hot. In early catarrhal salpingitis a mass is not felt. *Pelvic examination*

When the inflammation is associated with much exudate then a firm, tender, irregular mass will be felt in one or other fornix or in the pouch of Douglas. If inflammation is extensive it may be impossible to feel the uterus as a separate structure.

A rectal examination allows more of the pelvic peritoneum to be felt, especially that of the pouch of Douglas. *Advantage of rectal examination*

4. DIFFERENTIAL DIAGNOSIS

(1) Appendicitis

The most common condition for which acute salpingitis is misdiagnosed is appendicitis.

The classical picture of appendicitis, as described by J. B. Murphy in the first paper he presented to the Chicago Medical Society in 1889, still stands as a monumental contribution to the subject. "First there is pain in the abdomen, sudden and severe, followed by nausea or vomiting most commonly between three and four hours after the onset of pain. Then there comes a generalized abdominal sensitiveness most marked on the right side, and more particularly over the appendix, beginning from two to twenty-four hours after the onset of pain. These symptoms occur almost without exception in the above order; *Distribution of pain*

and when that order varies I always question the diagnosis. If nausea and vomiting or temperature precede the pain I feel the case is not one of appendicitis."

In salpingitis the alimentary disturbance is not so marked but headache may be a prominent feature. The pain is usually on both sides as the condition is bilateral. Previous gynaecological symptoms would point to inflammation of the tubes rather than the appendix. Temperature is higher. The attack may be ushered in by a sudden vaginal bleeding.

(2) Ectopic gestation

In the acute type with rupture of the tube the presence of severe intraperitoneal haemorrhage presents a characteristic picture. It is in the subacute or chronic type (haematocele) that the diagnosis may be confused.

A careful history will usually reveal some kind of menstrual irregularity. Uterine bleeding often follows the initial attack of spasmodic hypogastric pain. Signs of acute inflammation will be absent.

(3) Threatened abortion

Uterine contractions

Previous amenorrhoea, signs of pregnancy, backache, rhythmical painful uterine contractions with bleeding preceding the initial pain serve to distinguish.

(4) Torsion of ovarian cyst or hydrosalpinx

With torsion of an abdominal viscus there is pain and vomiting. These are simultaneous (Cope, 1946). Symptoms are more acute and on vaginal examination a tumour, round and distinct from the uterus, will be felt.

(5) Pelvic endometriosis

Fever and other signs of inflammation will be absent.

(6) Torsion of a fibroid

The pre-existence of the fibroid may have been known. Pain is more localized, and it may be possible to feel the tumour attached to the uterus.

5. TREATMENT

The treatment of acute salpingitis is usually non-operative. The defensive reactions of the body limit the spread of inflammation by forming adhesions. By operating, these protective adhesions are broken down and the infection disseminated. Even suppurative salpingitis with much exudate in time becomes limited.

Importance of Conservatism

Subsequent pregnancy

It is difficult to resist removing one or both tubes when brought to view in a laparotomy wound. Red, oedematous, turgid—they present to the naked eye such an advanced state of disease that removal seems to be indicated. Yet it is surprising how such an inflammation resolves itself with the tubes functioning normally as shown by a subsequent pregnancy. In the past many were the women who had their tubes and ovaries removed unnecessarily. Thus in the great majority of cases treatment is conservative.

(1) General measures

Heat to abdomen

With the patient in bed in Fowler's position heat is applied to the lower abdomen preferably by means of an electric pad (electrotherm).

A radiant-heat cage is also helpful. For 48 hours liquids only should be taken. Sedatives are necessary, but morphine should be avoided if possible. The pulse rate should be recorded at half-hourly intervals.

(2) Specific treatment

Sulphonamide therapy (with or without penicillin) is indicated, particularly if this can be properly controlled. The type of organism should be determined and a blood count is necessary. The organism should be tested for its sensitivity to penicillin. *Sulphonamides and penicillin*

(3) Physiotherapy

Short-wave pelvic diathermy is one of the most notable advances in the treatment of pelvic inflammation. Not only is it curative but it is also prophylactic for sterility. The induced hyperaemia prevents the permanent organization of the initial filmy adhesions which cause tubal stenosis and kinking. This treatment must be supervised by a competent physiotherapist. *Short-wave pelvic diathermy*

6. INDICATIONS FOR SURGICAL INTERVENTION

If under adequate conservative treatment the inflammation appears to be spreading above the pelvic brim then operation will probably be necessary. The case is now one of general peritonitis. Extension of pelvic peritonitis is more common during the puerperium than after gonorrhoea. With spreading peritonitis the original diagnosis may be at fault or a double lesion present such as appendicitis and salpingitis. *Peritonitis spreading*

7. OPERATIVE TREATMENT

In the event of the pelvic peritonitis spreading then laparotomy with drainage is indicated. Drainage can be done either abdominally or through the posterior fornix into the vagina. A specimen of pus for culture should be obtained. The pelvic cavity is dusted with some form of sulphonamide powder. *Drainage*

8. POST-OPERATIVE CARE

The treatment is the same as for peritonitis—a sulphonamide, or penicillin.

Short-wave pelvic diathermy should be started within a few days of the operation.

PART II

CHRONIC SALPINGITIS

1. AETIOLOGY

This necessarily follows on an acute attack, and adhesions become organized. The walls of the tubes are infiltrated with plasma cells and become thickened and nodular. *Adhesions*

With closure of the abdominal ostium a hydrosalpinx may develop, its content of serous fluid being sterile. A pyosalpinx may result. Usually the pus is sterile but sometimes it becomes secondarily invaded by *Bacillus coli* or other organisms. Where there has been long-standing chronic inflammation adhesions are very dense and bind the intestines to the genital organs. *B. coli pyosalpinx especially after menopause*

2. CLINICAL PICTURE

Multiple symptoms

Women suffering from chronic genital inflammation may show the whole range of gynaecological symptomatology—backache, pelvic pain, dyspareunia, menorrhagia, dysmenorrhoea, leucorrhoea, dysuria, constipation, fatigue and neurosis. At times there are acute exacerbations of pelvic inflammation.

3. SPECIAL AIDS TO DIAGNOSIS

It is notoriously difficult sometimes to differentiate between an inflammatory and non-inflammatory mass in the pelvis. There are two aids in this differential diagnosis.

(1) Blood examination. Leucocytosis and raised sedimentation rate would point to inflammation.

(2) Protein-shock therapy. Injection of milk (10 cubic centimetres of Aolan intramuscularly) induces a severe reaction with subsequent general and local improvement when the mass is inflammatory. With a neoplasm there is a minimal reaction and local changes are absent.

4. TREATMENT

This is either conservative or operative. Palliative treatment consists of improving the general health, treating anaemia, and prescribing sedatives and rest at the time of menstruation. Short-wave pelvic diathermy can also be given a trial.

5. INDICATIONS FOR SURGICAL INTERVENTION

Surgery is indicated when conservative measures fail and symptoms persist, when there are exacerbations of acute salpingitis or when there is a persistent pelvic mass.

There is always more danger when operating upon streptococcal cases. Crossen and Crossen (1944) have reviewed 3,600 cases of chronic pelvic inflammation (excluding tuberculosis) and found that the tubal contents were sterile in more than half the number. In this group even if the pus were spilt into the pelvic cavity there is little danger of peritonitis developing. The persistence of virulence depends upon the type of organism, that is, gonococcus or streptococcus. With the former pus becomes sterile after three or four months; with the latter the infection may remain latent for a much longer time, but the risk of operating in this group has been much diminished by the introduction of chemotherapy and penicillin.

6. OPERATIVE TECHNIQUE

With chronic salpingitis there is concomitant oöphoritis to a greater or lesser degree. Adhesions of varying thickness contribute to the difficulties of the operation which may be one of the most testing in pelvic surgery. The common type of case is that in which the tube is obviously chronically inflamed. Omental and intestinal adhesions may conceal the uterus and adnexa.

Position

The patient is put into the Trendelenburg position at the outset of the operation. The abdomen is opened by a median hypogastric incision. Omental and intestinal adhesions are separated after which the uterus and adnexa will be

fully exposed. The fundus of the uterus should be grasped with swab-holding forceps at the cornua or insertion of the round ligaments. This helps to put adhesions on the stretch. Hot packs control oozing and also wall off the general abdominal cavity.

By pulling on the fundus, the posterior wall of the uterus will be exposed, and then by gentle digital manipulation a line of cleavage will be found between the back of the broad ligament and the adnexal mass. Gradually the mass is freed and lifted into the wound. *Mobilizing the mass*

Constant care must be taken not to injure the intestines, particularly the rectum, since the mass may be firmly adherent to the bottom of the pouch of Douglas. If complete separation from the gut is impossible then the adherent portion should be left attached to the intestine. Thus a fistula can be avoided.

Before any excision is attempted the other tube and ovary should be examined, and a decision reached as to whether any ovarian tissue can be conserved on one or both sides. *Conservation of ovaries*

(1) Removal of tube

The tube is freed from adhesions and the mesosalpinx is clamped in sections beginning from its outer margin. The uterine end of the tube should be removed by means of a wedge-shaped excision. The clamps are replaced by ligatures, the outer pedicle being transfixed. The bleeding cornu of the uterus is controlled with a seromuscular suture. The area should be peritonized by using the round ligament.

It is most important that the whole length of the tube should be removed. If part of it is left this may become the site of infection at a later date, or of recurrent ectopic gestation. *Total removal of tube*

(2) Removal of tube and ovary

The ovary and tube are freed as much as possible and the infundibulo-pelvic ligament ligatured by transfixion; the utero-ovarian ligament is treated similarly. The tube is excised from the uterus and the further steps are as described in (1). Stumps are peritonized by using the round ligaments.

(3) Retrograde salpingectomy

In cases in which the abdominal end of the tube is buried and the infundibulo-pelvic ligament cannot be easily exposed, it is easier to commence the dissection from the uterine end of the adnexal mass. In this way it can be gradually visualized.

(4) Removal of uterus

When both tubes and ovaries have to be removed then a hysterectomy should be done in addition.

If oozing is excessive, or much pus has been spilt, a drainage tube should be inserted. In the former the tube need be left in at most for 36 hours, whereas in the latter it may have to remain longer and one can only be guided by the patient's progress as to when it should be removed. *Drainage*

7. POST-OPERATIVE CARE AND COMPLICATIONS

These are the same as with any other abdominal operation. Retention of urine, paralytic ileus and infection of the wound are more likely when there

has been an extensive dissection and exposure of pelvic contents. Their recognition and treatment is described in the relevant sections.

8. TUBERCULOUS SALPINGITIS

The symptoms of this disease are very similar to chronic salpingitis and therefore the condition is rarely diagnosed before laparotomy.

Amenorrhoea and sterility in the absence of a history of previous gynaecological disease point to the diagnosis and so does evidence of tuberculosis elsewhere. The Mantoux test is a special aid.

In about 50 per cent of cases the endometrium is also involved and a careful curettage does not disseminate the disease.

Treatment

In the ascitic form with tubercles visible on the peritoneal coat of the tubes, the tubes should be removed and the abdomen closed without drainage.

Pyosalpinx is treated by bilateral salpingectomy. In a young woman the ovaries should, if possible, be conserved.

Generalized tuberculosis of the pelvic viscera

Operation in these cases is fraught with the danger of injuring the intestine and bladder. If the tubes cannot be removed without extensive dissection it is better to close the abdomen without further interference. X-ray therapy is beneficial in such cases.

X-ray therapy

Drainage is to be avoided owing to the risk of a refractory tuberculous sinus developing.

In all cases general anti-tuberculosis measures are indicated.

PART III
ECTOPIC GESTATION

1. DEFINITION AND AETIOLOGY

A pregnancy developing outside the uterine cavity can be classified as (1) interstitial, (2) isthmic, (3) ampullary, (4) ovarian and (5) abdominal (Fig. 25).

Age and situation

Between the ages of 20 and 38 is the most common age. The ampullary portion of the Fallopian tube is the commonest site.

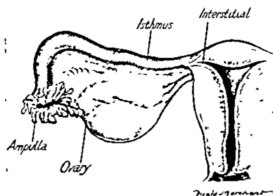


Fig. 25.—Sites of ectopic gestation.

Schauffler *(1945)* has analysed the aetiological factors of a series of cases as follows:

Twenty-one per cent of the patients had had some form of previous pelvic laparotomy, including appendicectomy.

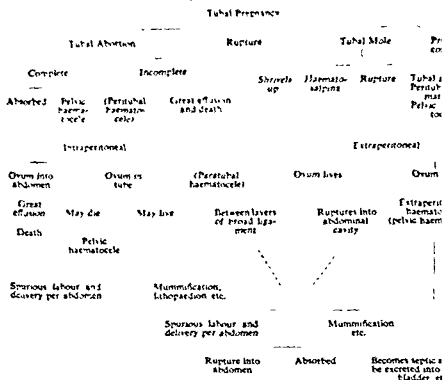
A history of previous

abortion was given by 35 per cent; 15 per cent had been curetted (
not pregnant).

Recurrent ectopic pregnancy has an incidence of about 3 per cent.

Salpingitis is a common aetiological factor since the inflammation may
a partial stenosis of the tube.

A tubal pregnancy may terminate in various ways and these are
marized schematically as follows:



*(Reproduced from "Practical Handbook of Midwifery and Gynaecology" by Haulta
Kennedy.)*

2. CLINICAL PICTURE

Symptoms and signs will vary according to the site and development
ovum and the pathological process involved. Ectopic gestation can
many other abdominal conditions, and it is for this reason that the diag
is missed. It is only by careful evaluation of history, symptoms and sign
mistakes will be avoided.

(1) Before rupture

The history of irregular menstruation is significant. After careful inter
tion the patient will often admit to some recent menstrual irregularity
period may be only one day overdue or, on the other hand, bleeding m

Uterine bleeding

Irregular bleeding has been mentioned above. It usually follows the initial bout of pain. This bleeding may be coincident with the death of the embryo. At this time a decidual cast may be expelled and when seen is pathognomonic of the disease.

Signs

On abdominal examination, pain may be elicited on deep palpation in the hypogastric region. On pelvic examination, *the uterus will be enlarged* and a soft, round, tender swelling may be felt at the side of the uterus. Pulsation may be present.

(2) Rupture and internal haemorrhage

This is the catastrophic type of case but fortunately it is rare. There may be a history of delayed menstruation. Abdominal pain is acute and accompanied by the typical signs of internal haemorrhage. Vaginal bleeding is often slight.

Shoulder pain

When there is much free blood in the abdomen pain is sometimes felt over the shoulders owing to diaphragmatic irritation.

The abdomen presents a diffuse fullness and it is tender. On pelvic examination a swelling may be felt in one or other fornix and the pelvic peritoneum is sensitive.

Tubal abortion

When tubal abortion is incomplete the clinical picture may be similar but less severe. A mass is usually felt. Often there are recurrent attacks of haemorrhage and later a pelvic haematocele develops.

The abortion may be complete in which case the patient complains of faintness, sudden hypogastric pain and slight vaginal bleeding. A spontaneous cure results.

(3) Pelvic haematocele

Usually there is a history of abdominal pain, faintness and uterine bleeding. The patient may be ambulant. There may be repeated attacks.

Pouch of Douglas acutely sensitive

On examination the patient may look anaemic. There is distension and tenderness of the lower abdomen. On pelvic examination an irregular mass will be felt in the pouch of Douglas. The uterus and cervix may be pushed upwards and forwards so that the latter is difficult to reach. The *posterior fornix is particularly tender and the patient retreats up the bed from the* examining finger. Pulsation in one or other fornix will sometimes be felt.

Siegler (1945) has evaluated the symptomatology in 127 consecutive cases of ectopic pregnancy. Abdominal pain, usually unilateral, occurred in 78 per cent. In 49 per cent menstruation occurred at the usual date but was prolonged or "spotting"; it was delayed in 38 per cent and in 13 per cent of this group the vaginal loss started concurrently with other symptoms. In nearly all cases there was abdominal tenderness and a mass was palpable in one or other fornix.

3. SPECIAL AIDS TO DIAGNOSIS

Puncture of the posterior fornix (posterior colpotomy)

This is a very valuable aid for the detection of blood in the pelvic cavity and it should be resorted to more frequently.

The patient is placed in the lithotomy position and the vagina cleansed with antiseptic. The posterior fornix is exposed by means of a speculum. The posterior lip of the cervix is steadied with a volsellum. A wide-bore needle with syringe attached is pushed through into the pouch of Douglas. It

should be kept parallel and close to the posterior aspect of the cervix. If blood is freely aspirated into the syringe the test is positive.

If there is still doubt about the diagnosis, the posterior fornix should be deliberately incised and a finger inserted into the pouch of Douglas.

In the tropics the writer has found this aid of value. There, one finds women already suffering from severe anaemia due to some other condition, for instance, ankylostomiasis. In the presence of such anaemia it may be difficult to decide whether there is also a superimposed ectopic gestation aggravating this state.

4. DIFFERENTIAL DIAGNOSIS

(1) Unruptured tubal pregnancy

(a) Appendicitis

It is easy to confuse this condition with ectopic gestation when this is on the right side. Cope has tabulated the main points as follows:

Condition	*Symptoms of an unruptured inflamed appendix*	*Symptoms due to an unruptured (but possibly leaking) tubal gestation*
Menstruation	Usually regular	Usually some irregularity
Uterine bleeding	Usually none	Usually present
Initial pain	Epigastric	Hypogastric
Fever	Slight	Usually none
Vomiting or nausea	Present	Unusual
Bimanual examination	Tenderness but no movable lump	A tender rounded movable swelling to one side of the uterus

(b) Uterine abortion

In this condition bleeding usually precedes the pain which is less severe. Bleeding is greater and the uterus larger in size and without a lateral swelling. Signs of pregnancy are more definite.

Where there is an intra-uterine pregnancy with a small ovarian cyst, hydrosalpinx or pyosalpinx the diagnosis from ectopic gestation is particularly difficult.

(2) Intraperitoneal rupture and haemorrhage

The typical signs of internal haemorrhage should serve to distinguish this condition from a perforation of an abdominal viscus—stomach, duodenum and so on. The acute onset in a person who was previously well and who gives a history of menstrual irregularity will help in the differentiation.

(a) Twisted ovarian cyst

This is not accompanied by much collapse. Vomiting and pain are often coincident. The discrete swelling of the cyst may be felt.

(b) Ruptured follicle cyst or corpus luteum

With severe internal haemorrhage the signs are indistinguishable. This condition is exceptionally rare.

(3) Haematocele

(*a*) *Retroverted gravid uterus*

In this the urinary symptoms are more marked. After passing a catheter the outline of the gravid uterus can be identified. There is not the marked tenderness in the pouch of Douglas as in haematoma, and the cervix is higher and pointing forward.

(*b*) *Adnexitis*

In this there may be a history of previous infection. Menorrhagia, and not amenorrhoea, is common. The mass is not so tender.

(*c*) *Pelvic appendicitis*

The history of menstrual irregularity and continuous bleeding is common in haematocele. Pulsation may also be present. The classical sequence of symptoms in appendicitis should assist in the differentiation.

(*d*) *Pedunculated fibroid*

A fibroid will be movable, harder and less tender. The history will be helpful.

5. PRE-OPERATIVE MANAGEMENT OF PATIENT

Estimation of the haemoglobin and determination of the blood group are routine measures. The level of the blood-pressure will indicate whether a blood transfusion is immediately necessary. When anoxia is marked oxygen given through a B.L.B. mask is helpful.

6. OPERATIVE TECHNIQUE

(1) Acute tubal rupture with internal haemorrhage

The incision is median and hypogastric. The dictum of "quickly in and quicker out" is particularly applicable. A suction apparatus is especially useful.

The hand is inserted behind the uterus, and one or other tube delivered into the wound and inspected. The diseased tube is rapidly excised by clamping its uterine end and the mesosalpinx. The pedicles are ligatured together so as to diminish the raw surface.

Ovaries should be conserved in all cases. Any additional operative procedures are to be condemned. Blood clots are removed and the abdomen closed without drainage.

Auto-haemo transfusion

This can be given when there is much fresh blood in the abdominal cavity and when a haematocele is absent; a small ladle is used to remove the blood from the abdomen to a flask containing citrate. Care must be taken to filter the blood through several layers of gauze.

(2) Pelvic haematocele

The treatment of this is operative but in this type of ectopic gestation speed is not essential.

After separating intestinal adhesions the mass of blood clot is removed from the pouch of Douglas. If the capsule is found to be adherent to the bowel no attempt should be made to separate it. The appendix should not be removed since this procedure increases the risk of infection.

The abdomen should be closed without drainage.

7. POST-OPERATIVE CARE AND COMPLICATIONS

The treatment of anaemia due to previous blood loss is particularly important. Haemoglobin estimation and a blood count will indicate whether a blood transfusion is necessary or whether iron therapy will suffice.

BIBLIOGRAPHY AND REFERENCES

Cope, V. Z. (1946). *The Early Diagnosis of the Acute Abdomen*, 9th ed. London; Oxford University Press.

Crossen, H. S., and Crossen, R. J. (1944). *Diseases of Women*, 9th ed. p. 623. London; Kimpton.

Davis, L. (1938). *Surgeon Extra-Ordinary. The Life of J. B. Murphy*, p. 127. London; Harrap.

Nixon, W. C. W. (1937). *Brit. med. J.*, 2, 579.

Schauffler, G. C. (1945). *West. J. Surg.*, 53, 301.

Siegler, S. L. (1945). *N.Y. St. J. Med.*, 45, 1974.

[References to other titles are given under Fallopian Tubes in the Index Volume. The subject is also dealt with under the heading of Fallopian Tubes Diseases *in the British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 250.]

FASCIAL GRAFTS

BY W. EDWARD GALLIE, M.D., F.R.C.S., F.R.C.S.(C)., F.A.C.S.
PROFESSOR OF SURGERY AND HEAD OF DEPARTMENT, UNIVERSITY OF TORONTO, CANADA

1. INTRODUCTION

150.] The principle that fibrous tissues such as fascia lata and tendon may be transplanted from one place in the body to another and still continue to live has been throughly demonstrated both by histological studies and by clinical experience.

(1) Histological changes

Survival of graft

The histological changes after transplantation are those of a mild inflammation without any marked change, except a moderate oedema, in the graft itself. There is no suggestion of necrosis as the cells and fibres continue to stain well, and there is no evidence of invasion by capillaries or infiltration with leucocytes. In specimens recovered years after the transplantation there is nothing to indicate any great change in the tissue or that its physiological value had been markedly disturbed.

(2) Viability of transplanted fascia lata

Some writers have cast doubts on the viability of transplanted fascia lata on the ground that at a subsequent operation no trace of it could be found. The suggestion is that after transplantation the fascia dies and is absorbed. This,

however, has not been our experience either in experimental studies or in practical clinical work. In animals we have recovered the sutures unchanged after the lapse of two years, and in patients we have been able to recover specimens after several years. In one patient who had had a new inferior gleno-humeral ligament made of fascia lata for the purpose of preventing recurring dislocation of the shoulder, this new ligament was exposed after the lapse of ten years, and was found to have still all the characteristics of a roll of fascia lata.

To state that fascial transplants always live would, of course, be going much too far. We know that if thick pieces of tendon are transplanted the central portion undergoes necrosis and ultimate absorption. It is quite conceivable that if fascia were transplanted into the midst of scar tissue where the supply of lymph may be poor, necrosis may occur. The evidence is overwhelming, however, that if the sheets of fibrous tissue such as fascia lata are transplanted to a place in the same individual where there is a good blood supply they will survive unchanged. Time and again we have had the opportunity to examine anatomical fields in which strips of fascia lata had been inserted years before, and we have never failed to find them. *Good blood supply*

(3) Indications for transplanting fascia lata

The indications for using transplants of fascia all have to do with repairing anatomical defects. Thus it is in general use in the repair of injuries of tendons and ligaments and in the closure of various kinds of hernia. In a typical case, such as a gap in a tendon, the fascia must bridge the gap and be strong enough, both in itself and in its adhesion to the ends of the tendon, to withstand the strain to which the tendon is normally subjected. This means that not only is the strength and viability of the fascia of importance, but also that the strength of its adhesion to whatever structure it is sewn must be sufficient. It is failure in this adhesion that has accounted for many of the disappointments attending fascial transplantation.

(4) Subsequent healing

The healing in of a transplant of fascia resembles closely the healing of a wound in any fibrous structure. It is by means of ordinary scar tissue which is easily stretchable, quite unlike fascia lata or tendon. To depend upon the simple edge-to-edge apposition, therefore, of a transplant of fascia to some other fibrous structure, if the line of suture is likely to be subjected to strain, is simply setting the stage for a recurrence of the defect. It was failure to recognize this that led to so many disappointments when patches of fascia lata were used to fill in large openings in the abdominal wall. In order that strong healing may occur between a transplant and its bed it is necessary to overlap the edges considerably, the amount depending upon the anticipated strain, and to scrape all areolar tissue off the transplant and the bed to which it is sewn so that there is direct contact of the scarified fibrous tissue. *Importance of anticipating strain*

Dependence on healing by scar tissue, however, is always a matter of doubt and should be replaced if possible by some method of weaving the transplant into its bed.

(5) Method of weaving transplant into its bed

A good example is seen in the method of repairing large defects in the abdominal wall with sheets of fascia lata, the ends of which have been split

into many tails (Gallie, 1932). In preparing the hernial opening for the closure, after the removal of the sac, one avoids separating the wall into its layers as this definitely weakens it. The peritoneum is pushed back from the edge of the opening for an inch in order that the needle may be passed from within out-

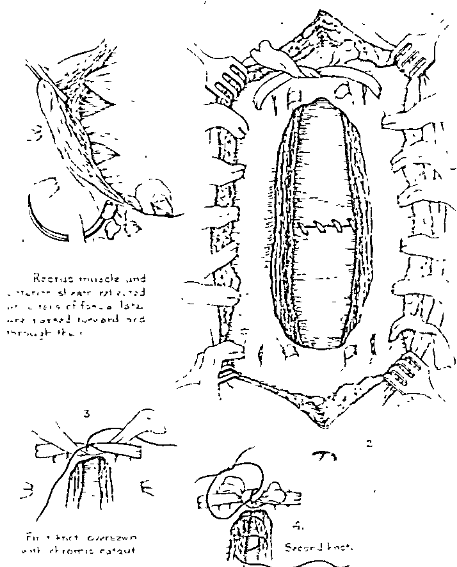


FIG. 26.—Illustrating technique of the repair of a large ventral hernia with sheets of fascia lata in which the ends have been split into many tails. (*Ann. Surg.*)

wards through the edge of the ring, without entering the abdominal cavity. If the hernial opening is longer than three and a half inches, it will be necessary to cut two patches which will be laid side by side across the opening. As a rule two patches of fascia, five inches by three and a half inches, can be obtained from the lateral aspect of a single thigh. The ends of the patches are then split into strips about a third of an inch wide which are threaded on a fascia needle and passed through the edges of the ring as shown in Fig. 26.

If a second patch is needed it is laid edge to edge with the first and the two are sewn together with a fine strip of fascia. At the ends of the opening special precaution is taken to weave the tails into the edge of the ring so as to prevent a protrusion over the end of the fascial sheet. When all the tails have been drawn through the abdominal wall they are tied together, each to its fellow of the opposite side, or each to its neighbour on the same side, and the edges of the opening drawn together as closely as seems safe. If they can be brought into contact without too much tension, so much the better, but if they cannot, the surgeon may rest assured that the deep side of the defect in the abdominal wall has been permanently closed off. When the edges of the hernial ring can be drawn together with moderate tension this is brought about by a deep chromic catgut suture which serves to take the tension off the fascia during the first two weeks. Often it is possible, when the deep portion of the opening cannot be brought together, to close the anterior sheath of the rectus or the external oblique aponeurosis with catgut, which undoubtedly adds to the strength of the closure. Care should be taken to oversew the knots in the tails of the fascia with catgut as they have a tendency to slip and untie when strain is put upon them.

Care in oversewing knots

2. NON-LIVING SUTURES

Strength and permanence aimed at

Much has been written about the closure of wounds and about the suture materials which will give strength and permanence to the closure. Catgut, kangaroo tendon and ox fascia on one side and silk, linen, cotton and steel wire on the other all have their advocates and all have their virtues in certain cases. When gaps have to be bridged, however, or when weak spots have to be strengthened nothing can take the place of living fascia, which not only has the necessary strength but can be depended upon to heal strongly to the bed in which it is sewn. If the principle of using the many-tailed sheets or of using long strips of fascia in the form of living sutures which are carefully woven into the walls of the opening is adopted, one need have no further concern about the solidity and permanence of healing.

3. LIVING SUTURES—TECHNIQUE

Fascial sutures are obtained from the lateral aspect of the thigh either through a long skin incision or, if one of the various fascia strippers is used (Fig. 27), through one or two half-inch incisions. The writer still uses the long incision on the ground that it provides accuracy in cutting the grafts and allows the closure of the gap in the fascial envelope of the thigh. It must be admitted, however, that very good sutures can be cut subcutaneously and that it is not often that the defect in the fascia lata causes symptoms.

Width of fascia

The width of the strips of fascia depends upon the purpose for which they are to be used. If it is intended to make a new inferior gleno-humeral ligament for the shoulder or a new crucial ligament for the knee, the strip should be an inch wide; if it is for the closure of a moderately sized ventral hernia a quarter of an inch or slightly wider is satisfactory; and if it is for the repair of a direct inguinal hernia slightly less than a quarter of an inch is correct.

Technique

The technique recommended is as follows. Through a long lateral incision the fascia lata is exposed and thoroughly denuded of areolar tissue over the

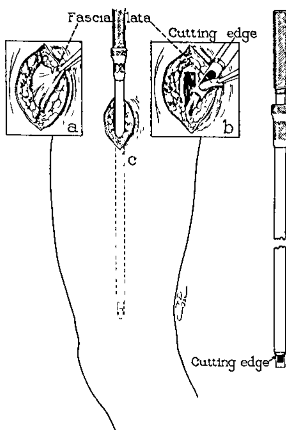


FIG. 27.—Masson's fascia stripper as developed at the Mayo Clinic. A wide strip of fascia is removed and is then split into sutures which are threaded on a needle. Dr. Masson reports using this stripper over 800 times himself. (*Proc. Mayo Clin.*)

desired length and breadth. The strip of fascia is then cut by ripping with scissors. Only one strip is removed from the wound at a time, and each is transferred to its final resting place with the least possible delay. Before it is removed from the thigh it has a fine silk ligature tied round one end, and the other end is tied securely into the fascia needle. It is then ready for use without immersion in salt solution and with a minimum of exposure to the drying effect of the air. Leaving strips of fascia in bowls of salt solution or lying about in dry towels would certainly seem to reduce the probability of survival. After the removal of each strip of fascia the skin wound in the thigh is closed temporarily with towel clips.

Some simple rules in technique must be obeyed to ensure success:

(1) Anchorage

Reinforcement of knot essential

It must be appreciated that living fascia is very slippery and that no knot will hold without reinforcement. That is the reason for the silk ligature tied round the end of the fascial suture. The needle is first passed through some strong aponeurotic structure and, if need be, through bone, and is then passed through the end of the suture, proximal to the silk ligature. (Fig. 28.) While this gives temporary security it is well to take a second anchoring stitch which transfixes the first knot and so makes certain of permanence. Where the strip of fascia is being anchored to bone a single knot is tied in the end of it, oversewn with catgut or fine silk, and when the fascia

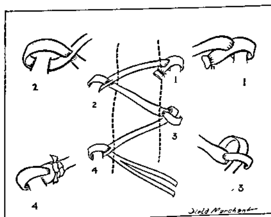


FIG. 28.—Diagrams illustrating points in technique in using living sutures. 1. Anchoring sutures. 2 and 3. Locking sutures. 4. Terminating sutures.

is drawn through a hole in the bone the knot, being larger than the hole, comes to rest against its edge.

(2) Termination of suture

To terminate the suture the needle should be removed and the end split into two equal tails for an inch or more. One of these tails is drawn under the main suture with a mosquito forceps and the two are then tied together with a triple knot oversewn with fine silk or catgut. At one time we used to attach a second fascial suture to the first, when more than one was necessary, but we now anchor and terminate each separately as this gives greater security.

(3) Relief of strain on living suture

Where structures are being brought together under strong tension as in incisional ventral hernias, it is wise to use some strong absorbable or non-absorbable suture to keep the strain off the living suture until it is healed firmly in place. Thus in closing the hernial opening we start the living suture and also a strong catgut suture at one end and make them progress along the opening together, with frequent lockings and transfixions. This gets away from the disagreeable experience of leaving chinks in the line of suture and places where the fascia has not been drawn sufficiently tight or has loosened.

Elimination of weak points in suture line

(4) Preservation of fascia

Avoid all abuse of the fascia, especially the application of clamps. Indeed, bear in mind constantly that it is intended that the fascia shall live.

These rules in technique are by no means absolute, and may be modified as suits the individual operator. The principles, however, should be remembered for there is no doubt that many failures have resulted from their neglect.

4. CLINICAL APPLICATIONS

The chief fields in which the transplantation of fascia is of value are (1) Injuries of tendons; (2) Injuries of ligaments; (3) Paralytic deformities of the face; (4) Hernia. It is not intended in this article to deal comprehensively with these conditions but simply to indicate the way in which fascial transplants may be used in their treatment.

(1) Injuries of tendons

When important tendons have been severed or avulsed from their insertion, and for one reason or another have not been repaired, the contracture of the muscle often makes it impossible to restore continuity without bridging a gap. This is most satisfactorily done with strips of fascia or tendon. It is not enough, however, simply to fill the gap with a neatly fitting transplant with end-to-end apposition, or even with overlap, because the strength of the union would depend solely upon stretchable scar tissue. One must rather weave the transplant into the end of the tendon so as to get a firm grip of it without dependence upon the process of healing. By weaving the fascia into the ends of the severed tendon it is possible to exert considerable tension and so bring them closer together and elongate the contracted muscle. It also allows early return to active movement without risk of tearing out the transplant.

The technique involves, first, the exposure of the severed tendon, then the preparation of suitable sutures of fascia ranging from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. in width,

depending upon the size of the tendon, and threading them on a thin needle and finally, weaving the suture into the ends of the severed tendon backwards and forwards across the gap and drawing them as closely together as they can be made to come. The ends of the tendon are not freshened as the scar tissue there is useful in preventing the fascial suture from cutting out.

Anchoring transplant

When the tendon has been avulsed from its insertion, as in avulsion of the tendon of the biceps from the tuberosity of the radius, the transplant is anchored to the radius by passing it through a hole through the bone at the normal point of insertion of the tendon and drawing it up until a knot which has been tied in the end of it comes to rest. The other end is then split into tails and woven into the end of the avulsed biceps under as much tension as the tissues will stand.

Variation in technique

Unsuccessfully treated injuries to tendons which normally are subjected to great strain, such as the quadriceps, ligamentum patellae and tendo Achillis, will all respond to treatment with fascial or tendinous transplants (Gallie and Le Mesurier, 1927a). In the case of the quadriceps, after the defect in the synovial membrane of the suprapatellar pouch has been closed off, stout fascial sutures are woven into the lower end of the tendon and then passed down through one longitudinal hole in the patella and back through another until the amount of fascia crossing the defect is sufficient to withstand normal strain. Similarly, old injuries of the tendo Achillis can be repaired, the technique varying as the rupture is close to the bone or higher up. It is well to make the exposure by the reflection of a skin flap in order that the repaired tendon may be adequately covered. The split tendon of the plantaris may be substituted for fascia. In ruptures and avulsions of the ligamentum patellae, fascia may be employed or better, strips of tendon. Under any circumstances the patella must be drawn down to somewhere near its normal position in order that the patient may ultimately have voluntary extension to 180 degrees.

(2) Injuries of ligaments

Here again the transplantation of the fibrous tissues has been of great value although attempts to replace ligaments which are normally always tight or are under frequent strain have been disappointing. Thus the operations in which the medial ligament of the knee or the anterior cruciate are replaced by fascia have all fallen short of perfection because the new ligament does not remain taut. No matter how carefully it is anchored into bone it loosens a little under strain, either by stretching of the adhesion or by actual change in shape of the bone. Where ligaments are not always taut, however, and only come into play occasionally to prevent dislocation of the joint, fascia makes a perfect substitute.

Recurrent dislocation of shoulder

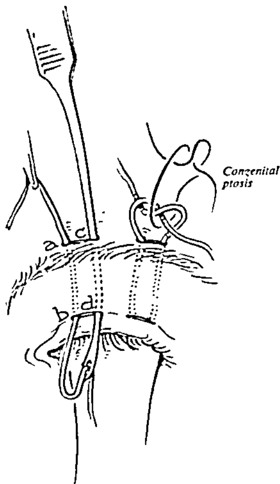
A good example is seen in the operation for recurring dislocation of the shoulder. This condition is due to a defect in the ligamentous support of the head of the humerus at the anterior border of the glenoid. It can be prevented by introducing a new inferior gleno-humeral ligament (Gallie and Le Mesurier, 1927b). This is not the time or the place to go into the details of this special operation. The results, however, have been highly satisfactory with a recurrence rate of 6 in 130 operations.

Other examples of repair of injured ligaments by fascia are seen in recurring dislocation of the patella and in dislocation of the acromio-clavicular joint,

when there has been rupture of the trapezoid ligament (*see* Fractures). The former may be prevented by tethering the patella to the internal condyle by fascia or tendon (Gallie and Le Mesurier, 1924), and the latter by making a new trapezoid ligament as described by Bunnell (1928).

(3) Paralytic deformities of the face

A good deal of use has been made of the principle of fascial sutures in the treatment of deformity of the face resulting from injury of the seventh nerve and in congenital ptosis (*see* Eyelids, Vol. 3, p. 509). Many techniques have been described but the neatest seems to be that of Wright (1922) for congenital ptosis. (Fig. 29.) I have seen a number of these patients and the results are beautiful and permanent.



Congenital ptosis

FIG. 29.—W. W. Wright's operation for congenital ptosis. The narrow strips of fascia lata make a permanent connexion between the drooping eyelid and the active occipito-frontalis and so enable the patient to raise it.

(4) Hernia

As this is the condition in which the transplantation of fascia has proved most useful the matter will be discussed in some detail. This is necessary because the recurrence rate after operation still continues high and because even after the introduction of fascial sutures recurrences have been reported.

(*a*) *Inguinal*

The first person to report the use of a suture made of fascia in the treatment of hernia was McArthur (1901). He used a strip split off the aponeurosis of the external oblique left attached at its inner end, and substituted it for the catgut or silk ordinarily used in the Bassini operation. The method proved excellent for the closure of uncomplicated inguinal hernias in young men.

But while in children, young women and most young men a cure can be brought about by any of the well-known methods, yet in others, such as in direct inguinal hernia in pot-bellied men and in recurred inguinal hernia of any kind, the cure is problematical and the recurrence rate is extraordinarily high. The reason is that in the former the only anatomical defect is the persistence of the funicular process of peritoneum, whereas in the latter there is a serious defect in the fascial and muscular structures of the abdominal wall.

Defect in abdominal wall

To reduce the recurrence rate in direct inguinal hernia or in any inguinal hernia which has already recurred, it is necessary to take the greatest pains to close permanently the abdominal defect on its peritoneal side. It is well to

remember that the normal posterior wall of the inguinal canal is the fascia transversalis, so that in all operations for inguinal hernia care should be taken to avoid injury of this structure, and every effort should be made to repair it when a hernia is already present. It is our practice to spend time in locating accurately the hole or weak spot in the fascia transversalis and in closing it with fine silk, so that the posterior wall of the canal is flat and is snugly closed at the internal ring. This gets rid of all bulging peritoneum, makes the sub-

Repair of posterior wall of canal

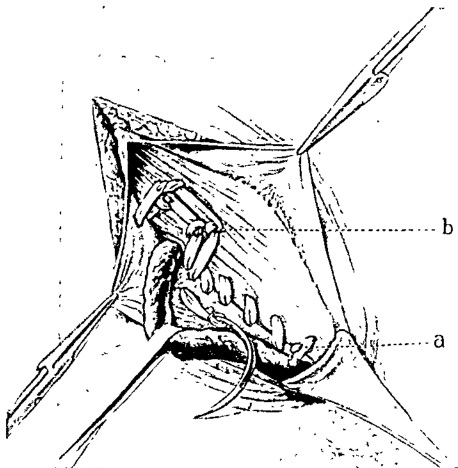


FIG. 30.—Diagram illustrating the repair of the inguinal canal with sutures of fascia lata in direct inguinal hernia: a, Slip-knot anchoring-stitch; b, lock-stitch. (*Brit. J. Surg.*)

sequent introduction of fascial sutures simpler and prevents the protrusion of peritoneum through chinks or weak spots in the final repair. No matter whether absorbable or non-absorbable or living sutures are used nothing will replace meticulous care in rebuilding the posterior wall of the canal. (Fig. 30.)

The anchoring of the fascial suture at the inner end of the canal is of the *utmost importance. It presupposes the thorough exposure of* the lower end of the rectus sheath and of the inguinal ligament at its attachment to the pubic bone. The needle is then passed through the lower end of the rectus sheath with a generous bite and then through the tail of the suture. When the suture is drawn tight a strong slip-knot is thus formed. To make absolutely sure that it will not pull out, however, we take a second bite of the rectus sheath and then

transfix the slip-knot. The needle then picks up the periosteum of the pubic bone and the expanded insertion of the inguinal ligament so as to close off completely the space between the rectus and the pubic tubercle. As this is the spot at which recurrences most frequently take place, we have often passed this first stitch through a hole drilled in the pubic bone, particularly in cases which have already recurred several times and in which the inguinal ligament has been

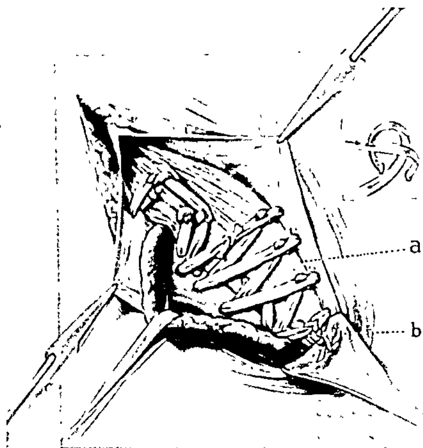


Fig. 31.—Diagram showing a supporting layer of sutures connecting the abdominal aponeurosis with the inguinal ligament. In practice these sutures are buried in the internal oblique muscle and form a filigree of living fascia: a, The line of junction of the aponeurosis of the internal and external oblique muscles; b, termination of suture. Inset shows most useful form of lock-stitch. (*Brit. J. Surg.*)

damaged or destroyed. The fascial suture is then used like any ordinary suture, to approximate the conjoint tendon and the internal oblique muscle to the inguinal ligament, behind the cord. The needle takes generous bites of the muscle and punctures the reflected portion of the inguinal ligament so that successive stitches do not pass through it in the same plane. This prevents splitting of the ligament. This first suture continues outwards until the internal ring is reached, and is then split and terminated as described under "technique". (Fig. 31.)

While in many instances the introduction of this single fascial suture is sufficient, this is not the case in bad direct hernias or in any inguinal hernias

that have had an extensive recurrence. These conditions require the building up of the posterior wall of the canal by weaving into it a filigree of fascia which catches the abdominal aponeurosis on the upper side and the inguinal ligament on the lower. Strips of fascia about ⅛ in. wide are used, threaded in a suitable needle. The sutures are buried in the internal oblique muscle and transfix and interlock with each other frequently. No set technique can be laid down as this must be devised by the operator as the situation presents itself. Our only advice is to put in enough fascia to make the posterior wall of the canal strong. If this is done, and if the anchorage of the sutures is adequate, and if the wound heals by primary union, the hernia will be cured.

No set technique

Some writers have complained of a high incidence of suppuration after using fascial sutures. This has not been our experience, however, and appears to be quite unnecessary if one avoids contamination of the wound from the skin and protects the sutures from exposure and abuse.

Since recommending the use of living sutures of fascia in the treatment of hernia it has been the fortune of the writer to be confronted with a large number of cases that have recurred three or four times after various kinds of operations. Some were closed with silk, some with wire, and, alas, some with fascia lata. A study of these cases has shown that the material used as a suture is not the sole answer to the problem of curing difficult hernias, but that to it must be added the skill and the care with which they are used. To leave a hole or a weak spot at the lower angle of the posterior wall of the canal or a defect in the fascia transversalis at the internal ring is simply asking for a recurrence. If one obeys the simple rules mentioned above, however, especially in regard to anchorage and weaving in plenty of narrow strips of fascia, eliminating all chinks and weak spots, recurrences will be exceedingly rare.

Adequate anchorage and weaving essential

Occasionally one is confronted with cases in which recurrence has taken place after multiple attempts at closure and in which the inguinal ligament has been so damaged as to be useless. In such cases we have stripped back the peritoneum to expose the pectineal ligament and then sutured the internal oblique and conjoined tendon to it with fascial sutures. As it is sometimes impossible to bring the internal oblique into actual contact with the pectineal ligament, and consequently chinks would be left between the strips of fascia, we have substituted a sheet of fascia about 1¼ in. wide, split into four tails at each end. These tails are anchored into the pectineal ligament on the lower side and the internal oblique on the upper. When these are tied together a strong sheet of fascia fills the space between the pubic spine and the femoral vein and forms what is really a new fascia transversalis. We have had successful results by this method in what seemed to be hopeless cases. A fine, curved mosquito forceps can be used to replace the needle.

(*b*) *Femoral*

Femoral hernia in which the ring is large or which has recurred after operation can be closed off with certainty by a single fascial suture uniting the reflected portion of the inguinal ligament to the pectineal ligament. If tied in loosely it does not compress the femoral vein but forms a sling across the mouth of the femoral canal which effectively blocks it. A strip of the external oblique is usually sufficient.

(c) *Umbilical*

When the hernial ring is small it can be closed effectively by one or two purse-strings made of quarter-inch strips of fascia. When it is larger it is safer to dissect the ring free of areolar tissue and to overlap the edges from above downwards and sew them in place with fascia. If there is much tension in overlapping the edges of the ring, the fascial suture is combined with heavy double catgut as described under "technique". When the ring is so large that there is no hope of closing it, the many-tailed sheet of fascia is used and, if this does not look strong enough, a second is superimposed on the first, with its fibres running at right angles to it. *Technique varying with size of hernial ring*

(d) *Post-operative ventral*

Small incisional hernias are simple and do not require living sutures. The large ones, however, present a major surgical problem both because of the technical difficulties and because of the tendency to post-operative ileus. Fortunately this latter has been largely overcome by the use of the Miller-Abbott tube. It is a good plan in the bad cases to put the tube down the day before operation and to make sure that it is through the pylorus; or if the hernia is in the neighbourhood of the stomach the tube may be passed at the time of the operation. *Miller-Abbott tube*

The technique after the removal of the sac and closure of the peritoneum is as described above under "technique". The combination of a double chromic catgut suture with the fascial suture is of great importance as it allows heavy strain to be applied in approximating the edges of the ring without the necessity of grasping the fascia with clamps. Without separating the edges of the ring into its layers, we start the catgut suture at one end, put in two or three stitches, draw it up tight and lock it. The fascial suture is then anchored and carried backwards and forwards across the wound with generous bites of the whole thickness of the ring. The catgut is then continued for several more stitches and locked, and then the fascial suture is brought up level. In this way the whole opening is closed without any abuse of the fascia and with the certainty that no peritoneum or pre-peritoneal fat can push its way between the fascial stitches.

When the hernial opening is so large that it cannot be closed, the combination of the many-tailed fascial sheet with catgut and with living sutures will give a flat, strong abdominal wall in many cases that might otherwise be considered hopeless.

(e) *Diaphragmatic*

As in umbilical and in post-operative ventral hernia, this condition is ideal for the use of living sutures. The first report of their use was made from this clinic by Janes (1931) and hundreds of cases have since been reported by Harrington (1940) and others. Recurrences have been practically eliminated.

The indications for using fascia in the treatment of hernia are: *Indications*

(1) Direct inguinal hernia.
(2) Oblique inguinal hernia in patients at or beyond middle life, particularly when the canal has lost its obliquity and when the abdomen has become pendulous.
(3) All forms of recurrent hernia.

(4) Femoral hernia in which the ring is large or which has recurred.
(5) Umbilical hernias in which the ring is large.
(6) Post-operative ventral hernias in which closure can only be accomplished with tension or in which complete closure is impossible.
(7) *Diaphragmatic hernia.*

The results, as indicated in thousands of cases reported during the past 25 years, have been fairly satisfactory. There have undoubtedly been failures but, in the cases we have had an opportunity to examine, these have been the result either of errors in technique or of insurmountable difficulties encountered in the operative field. Infection is, of course, most injurious. The fact, however, that fascia lives and heals firmly to those structures through which it passes gives it a quality possessed by no other suture material and enables it to achieve successful results where other methods have failed.

5. MISCELLANEOUS CLINICAL APPLICATIONS

(1) Movable kidney

Good results have been reported of cases in which the kidney was anchored to the last rib by strips of fascia passed round it in the form of a sling. The fascia is woven into the capsule and finally passed round the last rib and tied. All modern text-books on urology refer to this method.

(2) Arthroplasty

Autogenous fascia lata

Free grafts of autogenous fascia lata have been widely used in operations for the restoration of motion to ankylosed joints. The names of Murphy (1905), Putti (1921), Campbell (1921), MacAusland (1921) and others are closely connected with the published reports. The idea is that by covering the ends of the bones with living tissue and instituting early motion, a recurrence of the ankylosis could be prevented and useful voluntary movement retained. It has been my impression, however, after examination of a considerable number of cases, that while occasionally a brilliant final result can be shown, in most instances the result hardly justifies the operation. The best results seem to have been in the elbow, a non-weight-bearing joint, and the poorest in the knee.

(3) Vascular surgery

Haemorrhage risk reduced

Some use has been made of transplanted fascia in vascular surgery. When it is necessary to ligate large arteries such as the innominate or the aorta in continuity, the risk of fatal haemorrhage from ulceration of a ligature into the lumen of the vessel is greatly reduced by ligating with a band of fascia lata. Sheets of fascia have also been used to ensheath a segment of vein which has been used to bridge a gap in an artery after excision of an aneurysm.

From time to time reports have appeared of the successful use of patches of free fascia to fill gaps in hollow organs such as the bladder and oesophagus. These reports have remained isolated, however, and no practical use has been made of them.

Limitations

The truth is that there are limits to what we should expect fascia to do. It cannot replace mucous membrane or the intima of blood-vessels because these structures have physiological properties that fascia cannot simulate. But when anatomical defects such as occur in tendons, in the abdominal wall

or in the dura mater must be repaired, and when the damaged tissue resembles the fibrous tissue of fascia, then the use of free autogenous grafts of fascia lata is of the utmost value.

REFERENCES

Bunnell, S. (1928). *Surg. Gynec. Obstet.*, 46, 563.
Campbell, W. C. (1921). "Arthroplasty of Knee", *J. orthop. Surg.*, 3, 430.
Gallie, W. E. (1932). *Ann. Surg.*, 96, 551.
— and Le Mesurier, A. B. (1924). *Brit. J. Surg.*, 12, 289.
— — (1927a). *J. Bone Jt Surg.*, 25, 47.
— — (1927b). *Trans. Amer. Surg. Ass.*, 45, 393.
Harrington, S. (1940). *Amer. J. Surg.*, 50, 427.
Janes, R. M. (1931). *Can. med. Ass. J.*, 24, 421.
McArthur, L. L. (1901). *J. Amer. med. Ass.*, 37, 1162.
MacAusland, W. R. (1921). *Surg. Gynec. Obstet.*, 33, 223.
Murphy, J. B. (1905). *J. Amer. med. Ass.*, 44, 1573.
Putti, V. (1921). "Arthroplasty", *J. orthop. Surg.*, 3, 421.
Wright, W. W. (1922). *Arch. Ophthal., Chicago*, 51, 99.

[References to other titles are given under Fascial Grafts in the Index Volume.]

FAT NECROSIS

By GEOFFREY HADFIELD, M.D., F.R.C.P.

Sir William H. Collins Professor of Human and Comparative Pathology, Royal College of Surgeons of England; Formerly Professor of Pathology, University of London; Formerly Pathologist, St. Bartholomew's Hospital, London

1. INTRODUCTION

151.] Adipose tissue is as liable as any other connective tissue to undergo toxic, ischaemic or traumatic necrosis, and dead fat is dealt with by the standard methods of histiocytic phagocytosis and granulation-tissue replacement. The soaps and fatty acids produced by the autolysis of neutral fat delay the process of healing and are liable to become calcified. The mesenchymal reaction to them is characterized by the formation of multinucleated foreign-body giant cells containing crystalline fatty acid. For relatively long periods the lesion contains unabsorbed amorphous and crystalline material.

Products of autolysis of neutral fat

Definition

Whilst the above is a commonplace histological picture seen in a wide variety of necrotic processes, the term "fat necrosis" is applied to a relatively small number of conditions in which the necrosis is strictly limited to adipose tissue and has some special clinical, pathological or aetiological significance. In this restricted sense "fat necrosis" is encountered in the following conditions:

(a) Pancreatic fat necrosis.

(b) Traumatic fat necrosis of the breast.

(c) Sclerema adiposum neonatorum ("adiponecrosis subcutanea neonatorum").

2. PANCREATIC FAT NECROSIS

(1) Definition

This is the result of the direct action of extravasated pancreatic lipase on mesenteric and omental fat and on the interlobular fat of the pancreas itself.

Action of extravasated pancreatic lipase

(2) Mechanism of production

In the large majority of cases the extravasation of pancreatic juice follows rupture of some part of the duct-acinar system of the pancreas—the result of

high fluid pressure in the main duct system produced by obstruction at the lower end of the common bile-duct, caused by growth, fibrosis, cicatrization or stone. In a small minority of cases the escape of pancreatic juice is due to acute ischaemic necrosis of some part of the pancreas following thrombosis in an atheromatous pancreatic artery or in a number of degenerate small arteries and arterioles in cases of essential arterial hypertension, usually of the "malignant" variety. It may also result from lacerating trauma to the pancreas. It is very probable that the presence of regurgitated bile in the extravasated pancreatic juice speeds up its digestive action by activation of its enzymes, a process which will obviously be further accelerated by the presence of succus entericus.

(3) Association with acute pancreatic necrosis

With extensive extravasation, all the tissue elements of the pancreas are digested including the walls of its blood-vessels. Varying degrees of haemorrhage, acute oedema and gross necrosis of the substance of the gland are produced, and the condition known as "acute haemorrhagic pancreatitis" is produced. This lesion is more accurately described as acute pancreatic necrosis for, although infection by intestinal bacteria often supervenes and may result in suppuration, this is secondary to the direct necrosing action of trypsin and pancreatic lipase. The necrosis is usually obvious at operation, but the extensive liquefaction of the gland seen after death and described as "gangrene" is probably a post-mortem phenomenon. Acute necrosis of the pancreas varies considerably in severity but is almost always associated with pancreatic fat necrosis which can therefore be regarded as an indication of a grave pancreatic lesion, usually the result of disease of the biliary tract.

Haemorrhage, acute oedema and gross necrosis

Post-mortem phenomenon

(4) Gross appearances

Pancreatic fat necrosis presents at operation as firm, dry, strikingly opaque, white or grey nodules scattered in the pancreatic, mesenteric and omental fat, varying in size from a pin's head to a lentil, easily crushed and having the feel and texture of stearin. They are very occasionally found in the mediastinal fat. Occasionally the areas of necrosis are larger, flat and plaque-like and have a sinuous border. In jaundiced patients they are stained yellow. Recent lesions show a peripheral zone of hyperaemia. In a remarkably short time they become calcified. Histologically they are characterized by a complete absence of cell nuclei, and the presence of clusters of radiating acicular crystals of fatty acid and granular amorphous material.

Histological characteristics

3. TRAUMATIC FAT NECROSIS OF THE BREAST

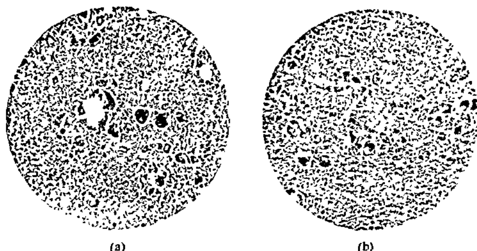
(1) Definition

This invariably benign lesion of the adipose tissue overlying the female breast consists of a mass of traumatized fat which, after a period of painless saponification by blood and tissue lipase, is slowly replaced by granulation tissue containing foreign-body giant cells, eventually contracts, often becomes cystic and occasionally calcified. Its sole importance lies in its liability, purely by virtue of its situation and strong tendency to cicatrize, to mimic the clinical signs of mammary cancer.

Simulation of mammary cancer

In most, but not all, of 45 recorded cases the patient was obese and the

breast fatty, pendulous or protruding. In 40 per cent there was a clear history of rather severe trauma to the breast, sometimes followed by ecchymosis of the overlying skin, and the lump appeared at the point of injury. There was no constant relation to lactation. On the average the patient had noticed the lump for 2½ months before seeking advice, but this period varied from 10 days to 2 years. In 66 per cent of cases the mass was hard or stony hard; in the



(a) (b)

FIG. 32.—Microphotographs showing cellular granulation tissue, containing many multinucleated giant cells. (a) A large giant cell containing a sheaf of acicular crystals. (b) Groups of giant cells massed around single cigar-shaped crystal clefts.

remainder it was firm, or firm with a central area of fluctuation. On clinical examination it was described as being the size of a bantam's egg, a lime, or a tangerine; its diameter varied from 7 to 1·5 centimetres. In 52 per cent of cases it was adherent to the skin, and fairly frequently the skin showed the *peau d'orange* change. The nipple was retracted in less than 10 per cent of cases. In 26 per cent of recorded cases a radical excision of the breast, pectoral muscles and axillary contents was carried out.

Peau d'orange

(2) Gross appearances

The most important feature of the pathology of fat necrosis of the breast is the naked-eye appearance of the lesion after local excision (Plate I). It is certainly possible to distinguish it from mammary cancer by gross examination.

In the early stages the focus of necrotic fat is white, dull, and strikingly opaque. It contains much neutral fat and the reactive zone at the periphery is pink but not cicatrized. It then becomes decidedly and typically chalky in appearance and is invaded irregularly by granulation tissue at the periphery. The centre becomes softened and a central pool of greasy fluid is often seen. At this stage the lesion contains an abundance of fatty-acid crystals, many being contained in multinucleate giant cells (Fig. 32). Following this stage the lesion becomes slowly and eventually completely encapsulated, and the central area of liquefaction becomes cystic and sharply walled off. Chalky fragments of unabsorbed fat remain in the lesion for a considerable time, but when they are finally absorbed no clue to the origin of the lesion remains.

Encapsulation of lesion


A


B


C


D

(A) Chalky-white mass with central area of liquefaction. Many small chalky particles lying in peripheral fibrous tissue. (B) Chalky mass with central area of liquefaction. (C) Similar lesion to that shown in (A), but showing more pronounced peripheral cicatrization. (D) Early encapsulation and central cyst formation. Progressive absorption of necrotic fat with cyst formation and commencing encapsulation.

PLATE I

Although firm, the excised mass is never so hard as a scirrhous cancer; when cut across it is never so well defined, and the cut surface does not show the same tendency to become concave. The white areas of opacity tend to be larger, whiter, more chalky, more irregular in shape, and do not radiate from the centre of the lesion in the same way as the yellow fatty streaks seen in a mammary cancer. *Distinction from scirrhous cancer*

4. SCLEREMA ADIPOSUM NEONATORUM

(1) Definition

This term has been applied to a rare and frequently fatal disease of the new-born in which there is an unexplained physico-chemical abnormality in the storage fat of the subcutaneous tissues, particularly affecting the fat of the back, buttocks, shoulders and cheeks, and occasionally that of the retro-peritoneal region and the mediastinum. *Physico-chemical abnormality*

(2) Gross appearances

In these situations the fat is abnormally solid and its contained stearin and palmitin strongly tend to crystallize out and to a lesser degree to hydrolyse with the production of fatty-acid crystals. Where such hydrolysis occurs sodium and calcium soaps appear in addition to unaltered fatty acid, there is a mesenchymal cellular reaction, the area is infiltrated by monocytes and foreign-body giant cells, the subcutaneous tissue becomes hard, rigid and putty-like in consistency, and the overlying skin thick, sclerotic and gross in texture! These changes, due entirely to non-pancreatic lipolysis, are considered to be secondary to a fundamental abnormality in the chemical make-up of the fat, possibly related to a deficiency in its olein content. Thus, whilst the histological picture may resemble that of traumatic fat necrosis of the breast, the disease must be regarded as having a totally different aetiology. *Lipolytic changes*

[References to other titles are given under Fat Necrosis in the Index Volume.]

FIBROIDS

See UTERUS

FIBROSITIS

By W. S. C. COPEMAN, O.B.E., M.D., F.R.C.P.
Physician-in-Charge, Rheumatism Department, West London Hospital; Medical Secretary, Empire Rheumatism Council

and

O. SAVAGE, O.B.E., M.R.C.P.
Chief Assistant, Rheumatism Department, West London Hospital; Deputy Medical Secretary, Empire Rheumatism Council

1. DEFINITION

152.] Fibrositis is a condition characterized by pain in the soft tissues, either local or diffuse, for which there is no obvious organic cause, and accompanied by tenderness, stiffness and muscle spasm without the general health being affected.

2. INCIDENCE

That this condition is extremely common is shown by the Registrar-General's recent figures—in the Emergency Medical Service Hospitals, 34 per 1,000 with a stay in hospital of 3 weeks for patients under 40, and of 4 weeks for those over that age. In the Service cases in these hospitals fibrositis accounted for 27 per cent of total admissions.

3. AETIOLOGY

There are various known causes of this condition.

(1) Trauma

This may be divided into:

(a) Macrotrauma

A single incident, such as an athletic injury, fracture or dislocation in which muscle and periarticular tissue are torn, with much haemorrhage and subsequent fibrosis, or sudden herniation of subcutaneous fat may be so classified. Such trauma may have taken place years before advice is sought for the subsequent fibrositis. *Injury*

(b) Microtrauma

This occurs during repetitive industrial work, for example to the backs of coalminers, to the forearms of mechanical-drill workers, and to the gluteal region and backs of gardeners.

(2) Infection

(a) General

Copeman (1943) has shown that during the course of many febrile illnesses, such as influenza, measles, rubella and mumps, small areas of fibrositis are often initiated. They remain latent and may be re-activated by a fever, unaccustomed use of the tissue in which they lie, by severe changes in temperature and by focal sepsis. *General infection*

(b) Focal

In older text-books focal sepsis is given as the main cause of fibrositis. During the last 30 years the results of the removal of foci, either obvious, doubtful or frankly conjectural, have been disappointing. There is no doubt that foci, such as apical dental abscesses or infected tonsillar remains, do play a part in the aetiology of this condition, but modern opinion relegates it to a lower place in the aetiological list than formerly. *Focal sepsis*

(3) Cold and wet

These have been postulated for a long time as causes of fibrositis. Before World War II many clinicians regarded the aetiological significance with some scepticism, but those who have lived with troops on active service are now convinced that these conditions can by themselves in certain circumstances cause fibrositis. *Climatic*

(4) Rheumatic fever

Patients who have suffered from rheumatic fever are prone to attacks of fibrositis throughout their lives. This is a well-known fact, although the exact *Sequel to rheumatic fever*

pathology of it is unknown, for though workers have attempted to show the presence of Aschoff node-like areas in soft tissue other than the myocardium, their efforts are not entirely convincing.

(5) Other rheumatic diseases

Accompanying other rheumatic diseases

Fibrositis plays a part in the symptom complex of such diseases as gout, rheumatoid arthritis and osteoarthritis. In rheumatoid arthritis the early symptoms of pain and stiffness around the joints are due to concomitant fibrositis, and in osteoarthritis the capsulitis and periarticular fibrositis are responsible for much of the distressing pain and limitation of movement.

(6) Postural deformities

As Wesson (1939) emphasized, muscle fatigue from prolonged misuse is a common cause of pain. Kyphosis, lordosis and abnormal pelvic tilts from postural deformities arising in adolescent or young adult life, and frequently initiated or aggravated by industrial conditions with abnormal positions whilst at work, often cause fibrositis.

(7) Psychological

This group must be included in any classification of fibrositis, for emotional upsets and the fatigue factor can undoubtedly cause this or similar conditions. Writers such as Halliday (1941) and some American writers believe it to be a major cause, and, though we do not agree with this and consider this type can be differentiated clinically, it must be recognized.

(8) Unaccustomed exercise

Any muscle group which is put into hard use after months or years of inactivity may develop fibrositis. Lumbago following the spring digging, or the attack of fibrositis after unaccustomed athletic activity, are examples of this.

4. MORBID ANATOMY

(1) Focal type of pain

In many cases of fibrositis the pain is referred from a focus which centres in a nodule or "trigger point", and it is necessary to study this conception more fully if a true picture of the condition is to be visualized. Pugh and Christie (1945) have recently observed in a Service group that "trigger points" were found in 30 per cent of rheumatic subjects, and only in 3 per cent of non-rheumatic subjects, and that non-tender nodules were found equally in both groups. In 1938 Kellgren published papers on the localization of pain from such deep structures as muscle, fascia and periosteum. He found that pain derived from superficial and deep fascia is confined to the neighbourhood of the point stimulated, whereas pain from muscle is felt diffusely and may be situated at some distance from the point injected.

Localization of pain

When hypertonic saline is injected into a muscle the pain is referred to regions corresponding to spinal segments from which its motor innervation is derived. This pain is deep and diffuse, and does not correspond with the sensory segmental pattern of the skin as described by Head. From Kellgren's work it is clear that pain from the deeper soft tissues may be referred to the region of a joint and may easily be confused with pain arising in the joint itself.

In 1920, Stockman published work on the pathology of nodules. He described the microscopical changes as inflammatory hyperplasia of connective tissue, which contained fibroblasts, more or less sero-fibrinous exudate, but no leucocytes. All cultures were sterile. He concluded that the local fibrosis was due to small colonies of microbes invading the tissue and causing a reaction which destroyed the invaders. He believed that the condition resulted from a general infection, but, as Collins (1940) points out, his most important findings were negative ones, that is, the absence of leucocytic infiltration of the nodules, and the sterility of the culture prepared from them. In fact it would seem that these fibrositic areas may more frequently be traumatic than infective in origin. Until recently this was the only recognized pathology, but since from clinical studies it did not appear to be the answer to all cases, instructed opinion had decided that it was unsatisfactory.

Original histological picture

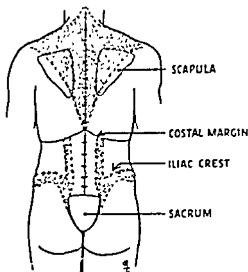


Fig. 33.—Sites in which "fibrositic" lesions of the fibro-fatty tissues are chiefly found.

Electromyograph studies

In 1944, Elliott, in examining certain "fibrositic nodules" by means of the electromyogram, found that these nodules were sometimes due to localized muscle spasm, and postulated that they were due to irritation of the posterior nerve roots by lesions in or around the spinal cord, such as prolapsed intervertebral discs or arthritis of intervertebral joints.

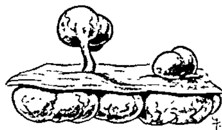


Fig. 34.—Drawing of pedunculated and non-pedunculated herniae of fibro-fatty tissues.

Fatty hernia

In the same year Copeman and Ackerman (1944) published the results of their post-mortem investigations. They found a basic fat pattern lying between the superficial and the deep fascia of the back, which extends across the shoulders into the supraspinatus tendons, down the sides of the sacrospinalis muscle, and out along the sacro-iliac junctions to lie above and below the iliac crests. This corresponds to the common areas for "trigger points" in fibrositis (Fig. 33). They found, moreover, that this fat can become herniated through weak points in the superficial fascia. These herniae are not infrequent, and they concluded that they are not pathological unless oedema or haemorrhage occurs in them (Fig. 34). They followed this work by biopsy examination in selected cases of fibrositis, finding that the palpable nodules removed were fatty herniae in which these changes had occurred, and

pathology of it is unknown, for though workers have attempted to show the presence of Aschoff node-like areas in soft tissue other than the myocardium, their efforts are not entirely convincing.

(5) Other rheumatic diseases

Accompanying other rheumatic diseases

Fibrositis plays a part in the symptom complex of such diseases as gout, rheumatoid arthritis and osteoarthritis. In rheumatoid arthritis the early symptoms of pain and stiffness around the joints are due to concomitant fibrositis, and in osteoarthritis the capsulitis and periarticular fibrositis are responsible for much of the distressing pain and limitation of movement.

(6) Postural deformities

As Wesson (1939) emphasized, muscle fatigue from prolonged misuse is a common cause of pain. Kyphosis, lordosis and abnormal pelvic tilts from postural deformities arising in adolescent or young adult life, and frequently initiated or aggravated by industrial conditions with abnormal positions whilst at work, often cause fibrositis.

(7) Psychological

This group must be included in any classification of fibrositis, for emotional upsets and the fatigue factor can undoubtedly cause this or similar conditions. Writers such as Halliday (1941) and some American writers believe it to be a major cause, and, though we do not agree with this and consider this type can be differentiated clinically, it must be recognized.

(8) Unaccustomed exercise

Any muscle group which is put into hard use after months or years of inactivity may develop fibrositis. Lumbago following the spring digging, or the attack of fibrositis after unaccustomed athletic activity, are examples of this.

4. MORBID ANATOMY

(1) Focal type of pain

In many cases of fibrositis the pain is referred from a focus which centres in a nodule or "trigger point", and it is necessary to study this conception more fully if a true picture of the condition is to be visualized. Pugh and Christie (1945) have recently observed in a Service group that "trigger points" were found in 30 per cent of rheumatic subjects, and only in 3 per cent of non-rheumatic subjects, and that non-tender nodules were found equally in both groups. In 1938 Kellgren published papers on the localization of pain from such deep structures as muscle, fascia and periosteum. He found that pain derived from superficial and deep fascia is confined to the neighbourhood of the point stimulated, whereas pain from muscle is felt diffusely and may be situated at some distance from the point injected.

Localization of pain

When hypertonic saline is injected into a muscle the pain is referred to regions corresponding to spinal segments from which its motor innervation is derived. This pain is deep and diffuse, and does not correspond with the sensory segmental pattern of the skin as described by Head. From Kellgren's work it is clear that pain from the deeper soft tissues may be referred to the region of a joint and may easily be confused with pain arising in the joint itself.

5. CLINICAL PICTURE AND DIFFERENTIAL DIAGNOSIS

(1) General symptomatology

As has been stated in the definition, the occurrence of pain with no general ill health characterizes this disease. Lewis (1938) pointed out that pain arising from deep structures is quite different from that from skin and mucous membranes, and is most uniformly described as "aching" pain. Fibrositis is a diagnosis which must be arrived at by a process of exclusion, for more lethal conditions may start with symptoms of pain and little generalized disturbance. Fibrositis should not be diagnosed without a general examination, bearing in mind such diseases as Hodgkin's disease, leukaemia, new growth, undulant and dengue fevers, periarteritis nodosa, chronic meningococcal septicaemia, Paget's disease of bone, and dermato-myositis. It must also be differentiated from hysteria and malingering, in both of which pain may be a presenting symptom.

Differential diagnosis for particular sites of affection will be dealt with under these headings.

(2) Epidemic myalgia

Bornholm disease

Bornholm disease has been recognized for nearly a hundred years. It is a febrile disturbance with severe pain in the chest and epigastrium accompanied by tender and swollen muscles.

Similar outbreaks probably occur in other muscle groups. An outbreak occurred in 1933 in Yorkshire (Pickles, 1933), and in 1944, in a factory in England, an epidemic of myalgia affecting the neck and arm was described.

(3) Fibrositis of the head and neck

The trapezius muscle, including its occipital aponeurosis and its surrounding fascia and fat, is one of the common sites of fibrositis. It causes pain in the neck which may spread over the head as far as the frontal region, and is a very common cause of headache. It must be differentiated from the headache caused by intracranial conditions, sinus infection and meningitis. The pain is usually worst in the morning and improves during the day, and is accompanied by some stiffness of the neck. Neither fever nor signs of raised intracranial pressure are present. On examination, tender "trigger areas" over the muscle are usually palpable and pressure on these will reproduce the symptoms.

(4) "Frozen shoulder"

This is the term often applied to fibrosing capsulitis of the shoulder joint. Any one of the pathological varieties may be present in the soft tissue round the joint. The supraspinatus muscle is prone to injury and fibrosis, calcification with subsequent rupture occurs in its tendon, and basic fat extends along its sheath and may become oedematous or herniated. The subacromial bursa may be affected by injury to either of its components, the deltoid and supraspinatus, and is liable to inflammation and calcification. The long head of the biceps ensheathed in the capsule is liable to fibrositis, and the deltoid is frequently injured by trauma in the region of the shoulder. The actual site of such lesions can be demonstrated by location of a "trigger point" reproducing the symptoms, and by putting the affected structure into action against resistance.

that removal cured the condition. It is probable that the pain in this type of fibrositis is primarily due to the increase in fluid tension in the affected lobules, and that actual herniation is a late effect of this.

(2) Diffuse type of pain

Though the majority of cases of fibrositis fall into the focal group there are a number where no focal pain points can be found. In these, a whole muscle group goes into spasm and causes the pain, and as the condition progresses this spasm becomes more and more easily initiated, so that when fully developed it is almost continuous. Examples of these are seen with general toxaemias, such as influenza and the local flood of toxin from an open focus of sepsis.

In the fibrositis due to unaccustomed use of a muscle group this diffuse spasm occurs. In psychological disorders, when fibrositis occurs, a whole *muscle group is usually affected, and in this group the fatigue factor* becomes prominent.

(3) Panniculitis

In this variety of fibrositis the subcutaneous fat is affected. It is associated with endocrine disturbances, such as the menopause and thyroid and pituitary dysfunction. The pain as in other types may be either local or referred in a segmental pattern. The common sites for this condition are across the shoulders, the lumbar and gluteal regions and the inner side of the knees.

For the purpose of clearer classification the following table has been drawn up in the light of our present knowledge.

PAIN	SITES	CLINICAL FINDINGS AT SITE	NATURE OF "TRIGGER POINT" OR LESION	CAUSE
1. Focal	Well-defined (as Fig. 33)	Nodule, palpable	1. Fibrous (Stockman) 2. Fibro-fatty (Copeman)	1. Strain Trauma Post-rheumatic fever 2. Trauma *Haemorrhage* Oedema Post-febrile
2. Focal	In course of muscle, anywhere	Nodule, palpable (possibly variable)	Local muscle spasm (Elliott)	Irritative focus within neural segment
3. Diffuse	Whole muscle groups	Tenderness	Unknown	(A) Toxaemia (i) General (ii) Focal sepsis (B) Over-use
4. Diffuse	Muscle groups	Spasm	Chronic fatigue	Psychoneurosis
5. *Diffuse*	Subcutaneous fat	Tender fat deposits (panniculitis)	Abnormal fat in deep subcutaneous tissue	Endocrine abnormalities

(8) Plantar fibrositis

The plantar fascia may be the seat of chronic and painful fibrositis. The commonest cause for this is a dropped longitudinal or transverse arch of the foot. However, there is a specific type of gonococcal fasciitis which affects the undersurface of the os calcis, sometimes with spur formation of the bone. There may also occur a type of fibrositis allied to Dupuytren's contracture in the hand.

(9) Panniculitis

This affection of the subcutaneous fat occurs frequently at the menopause. It is also seen in myxoedema, adiposis dolorosa, and other endocrine dysfunctions—most frequently across the shoulders, the lumbar pad, the gluteal region and the inner sides of the knees. The pain is diffuse and may be referred to other points in the same segment, and there is superficial tenderness and adhesion of the subcutaneous tissue to the skin, which dimples when it is pinched up. It must be differentiated from such conditions as rheumatoid arthritis or osteoarthritis of the neighbouring joints to which the pain may be referred.

6. PROGNOSIS

In fibrositis this depends upon the age of the patient and upon early treatment. With increasing age the muscles and periarticular structures become stiffer. If successive attacks are allowed to occur without adequate treatment adhesions form and it becomes more difficult to restore full function. If the condition becomes chronic secondary factors appear to complicate the picture. Muscle atrophy from disuse, postural deformities due to the pain of certain movements and secondary psychoneurosis all tend to follow in the wake of an attack of fibrositis, unless it is treated early and rationally. With adequate therapy, however, early attacks of fibrositis respond rapidly and recurrences can be avoided.

7. TREATMENT

(1) General

It has been the custom to advocate general rest in the treatment of this condition. Except when pain is crippling, as in acute lumbago, there is nothing to be gained by putting patients to bed, and in fact they improve more quickly if they are allowed to be up and about, and if possible, to continue their occupations. When the pain has responded to treatment a holiday is often necessary. This applies particularly to the psychogenic group where inner mental tension is translated into muscle spasm.

Clothing should be light and loose fitting to permit free ventilation and evaporation of perspiration, and this is best achieved by wearing porous or cellular material, either of linen or of wool, next to the skin. *Clothing*

The combination of cold and wet is unfavourable but may be difficult to eliminate. It is important to avoid damp houses and the neighbourhood of water, and good subsoil drainage is essential. Central heating is advisable where it is possible. *Climate*

Pain arising in the fifth cervical segment of the cord, either from irritation of the posterior root or from other lesions elsewhere in the segment, is localized around the shoulder and may give rise to fibrositis. In all these conditions the pain may be referred down the arm to the hand.

Fibrositis of the shoulder must be differentiated from specific lesions involving the fifth cervical root, such as prolapsed cervical disc or a spinal tumour, which will give neurological signs; from arthritis of the joint itself, and from bone affections of the clavicle, scapula and humerus, such as primary or secondary tumours and Paget's disease.

Since the demonstration of prolapsed intervertebral disc as a cause of referred pain the existence of pure brachial neuritis has become doubtful.

(5) Pectoral and intercostal fibrositis

These conditions are important because of their differential diagnosis. Fibrositis in the intercostal and pectoral muscles and surrounding structures with focal "trigger points" is common, but before a diagnosis is made such conditions as coronary disease and pericardial effusion, pulmonary disease, particularly neoplasm and effusion, and involvement of posterior root nerves by neoplasm and suppuration in the spinal canal and vertebrae, must be excluded.

(6) Lumbar fibrositis

Lumbago

This is frequently acute on onset, with painful spasm of the erector spinae muscle. The spasm can be relaxed in the prone position but palpation at this stage causes a recurrence, so that location of nodules may be impossible.

This acute condition is differentiated from meningitis by the absence of fever and neurological signs, or from vertebral collapse, tumour, caries or a spinal abscess, all of which will give signs of cord involvement.

In the more chronic forms of lumbar fibrositis the spasm and stiffness of the muscles is intermittent and the pain is localized to the small of the back. In these cases there is often a postural element due to either occupational or adolescent deformity. On examination, the normal lumbar curve may be exaggerated or reduced, with a pelvic tilt and kyphosis or scoliosis above. "Trigger areas" may also be present from old trauma, herniation of a fat lobule, or inflammation, so that there may be more than one factor to correct in the treatment. There are no abnormal neurological signs differentiating it from those due to increased extradural and intradural pressure. The main conditions to be distinguished are lesions of the vertebrae and prolapse of a lumbar disc. Such conditions as spondylolisthesis, Kümmell's disease, Pott's disease, ankylosing spondylitis and neoplasm will be differentiated by radiological examination.

(7) *Gluteal fibrositis*

In the area along the iliac crest and for 2 inches below, fatty herniae are common and haemorrhage may occur in them. The tendinous origins of both gluteus maximus and medius are also frequent sites for fibrositis. The pain may be referred down the back of the leg, causing sciatica, and as the lesion passes from the acute to the chronic stage, wasting of the gluteal muscles occurs, sometimes with some diminution of the ankle jerk. In fibrositis there are no sensory changes—which distinguishes it from the disc syndrome.

radiation, or if deeper penetration is required, long- or short-wave diathermy are other methods. Paraffin-wax foot baths are useful for plantar fibrositis.

Hydrotherapy is valuable for the more generalized forms and acts also as a general stimulant. It may be given in the form of brine or soda baths at a temperature of 102°–105° F. made by the addition of 1 pound of the medium to an ordinary bath, or by general douches. The parts should be massaged during the bath and movements performed. *Hydrotherapy*

Ionization with histamine to produce a weal is often effective in panniculitis and periarticular fibrositis. *Ionization*

Massage must be used with discrimination, as in the acute stage it will do harm, but in the more chronic stages it is well tolerated. Here it can be increased gradually from superficial to deep massage and will help to break down adhesions and disperse thickened areas after injection. *Massage*

Muscle wasting and postural deformity may remain after an attack of fibrositis. These must be corrected by means of exercises. If adhesions have formed, passive movements and sometimes manipulation under anaesthesia will be necessary. *Exercises* *Manipulation*

BIBLIOGRAPHY AND REFERENCES

Buckley, C. W. (1938). *Arthritis, Fibrositis and Gout*, p. 99. London; Lewis.
Collins, D. A. (1940). *Ann. rheum. Dis.*, 2, 114.
Copeman, W. S. C. (1943). *Ann. rheum. Dis.*, 3, 222.
— and Ackerman, W. L. (1944). *Quart. J. Med., N.S.*, 13, 37.
Elliott, F. A. (1944). *Ann. rheum. Dis.*, 4, 22.
Halliday, J. L. (1941). *Ann. intern. Med.*, 15, 666.
Kellgren, J. H. (1938). *Clin. Sci.*, 3, 175.
Lewis, T. (1938). *Brit. med. J.*, 1, 321.
Pickles, W. N., (1933). *Brit. med. J.*, 2, 817.
Pugh, L. G. C. E., and Christie, T. A. (1945). *Ann. rheum. Dis.*, 5, 8.
Stockman, R. (1920). *Rheumatism and Arthritis*, p. 41. Edinburgh; Green.
Wesson, A. S. (1939). *Proc. R. Soc. Med.*, 32, 275.
[References to other titles are given under Fibrositis in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 279.]

(2) Drugs

Pain

An initial purge using calomel followed by saline is a useful procedure. For pain one of the codeine compounds such as Veganin is valuable. If stronger measures are required, a mixture of amidopyrine with barbitone, such as Veramon, may be used. Where there is a psychological factor, either primary or secondary, with emotional disturbance, a general sedative such as Luminal grain $\frac{1}{2}$–1 should be given three times a day. If a gouty factor is suspected colchicine grain $\frac{1}{120}$ or Tinct. colchici. 15 minims, three times a day, should be tried.

Endocrine therapy

Where an endocrine factor is present, as in panniculitis at the menopause, oestrogen therapy should be employed. Preparations such as dienoestrol 0·3 milligram, 3 times a day, given from 7 days after the period date and to 2 days before it, and decreasing the dosage as the frequency of flushes fades, are used. This is combined with courses of thyroid gland.

Diet

Diet should be strictly controlled where weight is excessive, and with any gouty diathesis high purine foods such as sweetbreads, liver and kidneys must be forbidden.

(3) Septic foci

Septic foci should be searched for in the teeth, nasopharynx and prostate, and eliminated where obvious. As has been mentioned the results of the removal of doubtful foci alone have been disappointing.

Vaccines

Vaccines have proved of little value in treatment. Theoretically they may be tried where a suspected focus cannot be reached, but treatment with penicillin would seem more rational. If they are used the dosage should be small, and reaction avoided.

(4) Local treatment

Local injection

Following Kellgren's work the injection of local anaesthetics has become an accepted adjunct in the treatment of this disease. The principle of segmental distribution is followed, and the "trigger area" must be located accurately with reproduction of the symptoms both by pressure and by movement of the injecting needle. Fluid is injected into this area with the aim of stretching it by increased fluid tension, and where the lesion is a fatty hernia Copeman has introduced the method of undercutting with a sweep of the needle. Various solutions are used but, to spare the patient pain and to enable him to gain movement afterwards, the commonest is a local anaesthetic such as procaine $\frac{1}{2}$–2 per cent giving a certain analgesic effect for a few hours. The injection of 5–10 cubic centimetres into the area may need some force, but if the region has been accurately found, often a very difficult task, the symptoms will frequently be permanently relieved. When free from pain the patient should at once be encouraged to regain full movement.

Strapping

In acute fibrositis of the lumbar or plantar region, where spasm recurs frequently, support by strapping is of value. It will relieve the spasm and enable movement to restart gently.

(5) Physical methods

Heat

Physical methods are of value in the treatment of fibrositis but must be used rationally. Heat relieves the pain in both acute and chronic cases, and may be given locally by means of poultices, hot compresses or electric pads. Infra-red

6 months and the embryos (microfilariae) are hatched out. In many cases there are no symptoms, but in others an inflammatory reaction is set up with proliferation of endothelial and connective-tissue cells, and progressive obliterative lymphangitis, leading to fibrosis. Early biopsy of an affected lymph gland shows hyperplasia of lymph follicles with eosinophilic infiltration and oedema, and the adult worm may be found *in situ* (Thompson, Rifkin and Zarrow, 1945). The early changes are held to be an allergic reaction to toxins liberated from dead worms (O'Connor, 1932) and may take the form of urticaria with eosinophilia only, or of lymphangitis in heavy infestations (Acton and Rao, 1931). Obstruction to the lymph flow is accompanied by recurring attacks of lymphangitis, probably due to secondary streptococcal infection, the resulting fibrosis leading ultimately to elephantiasis (*see* Elephantiasis in Vol. 3, p. 362). Local abscesses may form round dead worms or from secondary staphylococcal infection.

Inflammatory reaction

Biopsy

Allergic reaction

Secondary infection

Microfilariae may be present in the blood at night in cases of 1–2 years' standing, but death of the worm or its enclosure by fibrous tissue may prevent them reaching the blood stream.

Microfilariae in blood

6. CLINICAL PICTURE

Many early cases of the condition were seen amongst American troops in the Pacific Islands. After about 5 months' residence the attack began with lymphadenitis of an arm or leg, followed by retrograde lymphangitis, with red streaks in the skin, tender knots along the lymph vessels or diffuse thickening of the subcutaneous tissues. Weals and itching appeared for the first few hours, accompanied by eosinophilia (Burhans and his colleagues, 1944). In severe cases, there is fever (101°–104° F.) with rigor, headache, vomiting and delirium, subsiding after a few days. Attacks may recur at intervals, leading ultimately to elephantiasis. Abscess formation may result from secondary staphylococcal infection.

Lymphadenitis and retrograde lymphangitis

In the American series the commonest early manifestation was scrotal funiculitis (185 of 251 patients; Dickson, Huntingdon and Eichold, 1943). At the onset, usually at night, sharp pain was apparent in the groin and testis, followed by inguinal lymphadenitis, epididymo-orchitis, effusion into the tunica vaginalis and oedema of the scrotal skin. The attack subsided after a few days, leaving permanent thickening, but recurrences were common (Burhans and his colleagues, 1944). In severe cases associated with secondary streptococcal infection, the onset is accompanied by rigor and high fever; lymph-scrotum and elephantiasis are late sequelae. Microfilariae may be found in hydrocele fluid in cases of about 2 years' standing. Involvement of the iliac and lumbar lymph glands, and of the retroperitoneal lymphatics may cause acute abdominal symptoms, and in secondarily infected cases retroperitoneal abscess or peritonitis may follow. The iliac fossae are common sites for these abscesses, but the longer history, the localization of the signs and the odourless pus found on incision will distinguish them from abscesses of intestinal origin.

Funiculitis

Retroperitoneal abscess

Adeno-varix is the term applied to a soft, lobulated, varix-like condition of the axillary or inguinal lymph glands, due to repeated attacks of filarial lymphadenitis. Adult worms may be found in sections or microfilariae in aspirated fluid. No symptoms are caused except during attacks of inflammation.

Adeno-varix

FILARIASIS

By W. L. HARNETT, C.I.E., M.D., F.R.C.S.
Lieutenant-Colonel, Indian Medical Service (Retired); Formerly Professor of Surgery, Medical College, Calcutta.

1. DEFINITION

153.] A condition caused by infestation with *Filaria* (*Wucheria*) *bancrofti* or *malayi*, which may be associated with secondary inflammatory changes.

2. AETIOLOGY

Parasite

Wucheria bancrofti or *malayi* is a nematode worm, the female of which is 65–100 millimetres × 0·3 millimetre. The adult worm lives in the lymphatic system, where reproduction takes place and the embryos (microfilariae), measuring 125–320 × 7·0 μ and enclosed in a sheath, are extruded and pass into the blood stream. *Transmission* Transmission is by the bite of a mosquito, usually one of the species of *Culex*. In the Samoan group of islands Dickson, Huntingdon and Eichold (1943) found that 13·6 per cent of natives had microfilariae in their blood, and Rao (1942) found that in Cachar the percentage might be as high as 28·2, but in only 4·5 per cent were any clinical signs present.

Infestation rate

3. GEOGRAPHICAL DISTRIBUTION

Filariasis occurs in tropical and sub-tropical countries from Southern Spain to Brisbane, in Arabia, India, South China, Japan, the Pacific Islands, tropical America and central and West Africa.

4. SURGICAL ANATOMY

The worms lie in the main lymphatics or in lymph glands. A tissue reaction may be set up by their presence, resulting in obstruction to the flow of lymph, the effects of which will vary according to the site of the obstruction. If it is in the thoracic duct there is dilatation of the thoracic and large abdominal lymphatics; if it is lower down in the iliac, femoral or inguinal lymph glands, the lymph drainage from the legs, scrotum or genital regions is interfered with. The upper limb, breast and scalp are affected more rarely.

Site of obstruction

5. PATHOLOGY

The immature parasite (microfilaria), after penetrating the skin, reaches the lymphatic system, where males and females grow to sexual maturity in about

applications. Buttle (1939) reports good results from Prontosil rubrum, 1·5 grammes daily for 6 days, but sulphonamides have been of little use in early cases (Dickson, Huntingdon and Eichold, 1943; Burhans and his colleagues. 1944). Rose (1919) reported prevention of relapse in 60 cases by vaccines of streptococci. *Sulphonamides*

Incision is necessary in abscess formation, and in severe funiculitis the inguinal canal should be freely laid open. Lymph varix of the cord may be excised and chronic hydrocele dealt with by the usual methods. Excision of the adeno-varix is not advisable, as it may be followed by lymphorrhagia, lymph-scrotum or elephantiasis, and the same danger attends radical treatment of chylocele, for which, if tapping does not suffice, incision and packing are preferable (Acton and Rao, 1931). *Operation*

BIBLIOGRAPHY AND REFERENCES

Acton, H. W., and Rao, S. S. (1931). *Ind. med. Gaz.*, 66, 11.

Burhans, R. A., Camp, J. D., Butt, H. R., and Cragg, R. W. (1944). *U.S. Nav. med. Bull.*, 42, 336.

Buttle, G. A. H. (1939). *Trans. R. Soc. trop. Med. Hyg.*, 33, 141.

Chopra, R. N., and Rao, S. S. (1939). *Ind. J. med. Res.*, 27, 549.

Culbertson, J. T., Rose, H. M., and Oliver-Gonzalez, J. (1945). *Amer. J. trop. Med.*, 25, 271, 403.

— — — (1946). *Amer. J. Hyg.*, 43, 145.

Dickson, J. G., Huntingdon, R. W., Jun., and Eichold, S. (1943). *U.S. Nav. med. Bull.*, 41, 1240.

Fairley, N. H. (1931). *Trans. R. Soc. trop. Med. Hyg.*, 24, 635.

Manson's Tropical Diseases, A Manual of the Diseases of Warm Climates, 12th ed. (1945). Ed. by Manson-Bahr. London; Cassell.

Michael, P. (1944). *U.S. Nav. med. Bull.*, 42, 1059.

O'Connor, F. W. (1932). *Trans. R. Soc. trop. Med. Hyg.*, 26, 13.

Rao, S. S. (1933). *Rep. Sci. Advisory Board, Ind. Res. Fund. Ass.*, 85, 1933.

— (1942). *Ind. J. med. Res.*, 30, 345.

Rose, F. G. (1919). *J. trop. Med. (Hyg.)*, 22, 81.

Stitt, E. R. (1945). *Diagnosis, Prevention and Treatment of Tropical Diseases*, 7th ed. Ed. by Strong. London; Lewis.

Thompson, K. J.; Rifkin, H., and Zarrow, M. (1945). *J. Amer. med. Ass.*, 129, 1074.

Wolfe, H. R. I., and Schofield, A. L. (1946). *Brit. J. Surg.*, 33, 395.

[References to other titles are given under Filariasis in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 301.]

Lymphorrhoea During attacks of lymphangitis there may be vesicle formation with escape of lymph on the surface of the skin. The most common situation for this to occur is on the scrotum (*see* Elephantiasis—Lymph-scrotum in Vol. 3, p. 364).

Hydrocele Hydrocele is more common in areas in which filariasis is endemic than elsewhere in the tropics (Rao, 1933). The fluid may be clear or milky (chylocele) and may contain microfilariae. The serous surfaces of a chylocele are often covered with patches of oedematous exudate and adult worms may be found in the cord or epididymis (Wolfe and Schofield, 1946).

Chyluria Obstruction of the thoracic duct, or of the abdominal lymph vessels communicating with those carrying chyle from the intestine, may lead to rupture of lymph vessels through the mucous membrane of the urinary tract, giving rise to chyluria, or haematochyluria if small blood-vessels also rupture. The onset of an attack is abrupt, preceded by pain in the back and thighs, and may be accompanied by fever. The attack lasts only a few days, but is liable to recur, causing increasing debility and anaemia. The urine during an attack is loaded with fat, and after standing a coagulum forms in which microfilariae may be found.

7. SPECIAL AIDS TO DIAGNOSIS

Blood and lymph films Thick films of blood taken between 9 p.m. and midnight should be examined for microfilariae, but these are not likely to be found in cases of less than 1–2 years' standing.

Eosinophilia, up to 28 per cent, is present in 30–40 per cent of early cases (Thomson, Rifkin and Zarrow, 1945). Fluid obtained by puncture of an enlarged lymph gland or from a hydrocele should be examined for microfilariae.

Biopsy A lymph gland or a nodule in a lymphatic vessel may be excised for examination for adult worms. This gave positive results in 36 of 120 biopsies (Michael, 1944).

Complement-fixation and skin test Complement-fixation and cutaneous reactions, using an antigen obtained from an extract of *Dirofilaria immitis*, were described by Fairley (1931). The skin test was positive in 87·3 per cent of the early cases in Samoa (Michael, 1944).

8. PROGNOSIS

Elephantiasis The prognosis is good, apart from the danger of secondary infection. Elephantiasis may develop after long residence in an endemic area and repeated reinfestation.

9. TREATMENT

Neostibosan No drug will destroy the parasites, though results of treatment with Neostibosan, 4·6–10·5 grammes in 33–54 days, are encouraging (Culbertson, Rose and Oliver-Gonzalez, 1946). Chopra and Rao (1939) found that Fouadin (total dose 80 cubic centimetres) caused temporary reducton of microfilariae in the blood, and cleared up attacks of chyluria; Soamin, 20 grains in doses of 2 grains, checked inflammatory attacks.

Removal of the patient from the possibility of reinfestation leads to cure by death and encapsulation of the worms. Attacks of lymphangitis or funiculitis should be treated on general lines by rest, elevation of the part and soothing

The term fistula means a pipe. As such, it consists of a fibrous main track with internal and external openings and, though these openings may heal, the main track lined by granulation tissue remains unhealed.

A fistula in ano arises as a result of infection, with abscess formation, in and around the anal canal and rectum. Nature's failure to obliterate the cavity by third-intention healing results in fistula formation and, consequently, surgical intervention is necessary before healing can occur.

Principle of surgical treatment

The principle of surgical treatment is to lay open the track of the fistula to the surface by division of overlying tissue and then to fashion the wound by *removing skin and fat in order to obtain healing by second intention.* The relationship of the sphincter muscles to the main track creates the surgical problem, since some division of muscle is usually necessary to lay open the main track throughout its entire extent.

3. SURGICAL ANATOMY OF THE ANAL CANAL

Important landmarks in palpation

In palpating the anal canal there are three important landmarks which are readily defined, namely, the *ano-rectal ring*, the *anal intermuscular depression* and the *subcutaneous external sphincter.*

An understanding of the structure of these landmarks, together with a knowledge of the functional importance of the ano-rectal ring and the relative unimportance of the subcutaneous external sphincter muscle, is essential if treatment is to be undertaken with confidence.

(1) Ano-rectal ring

This ring is composed of the following muscles.

(i) *Pubo-rectales muscles.*—These are the specialized portions of the levator ani muscle, which act as a sling. They pass from their origins on the posterior surface of the pubes backwards and slightly downwards on either side of the prostate or vagina to join together as the continuous sling of muscle at the ano-rectal junction. They are attached to the lateral and posterior aspects of the bowel, fusing with the longitudinal muscle of the rectum but, although their inferior borders lie close together in front of the rectum, they do not complete the muscle ring anteriorly.

(ii) *Deep part of external sphincter.*—This forms a complete ring of muscle lying just below and external to the pubo-rectalis sling with which its uppermost fibres are blended. Its inner surface embraces the longitudinal muscle and the internal sphincter. It will be seen that the deep external sphincter fills a gap anteriorly, in the incomplete circle formed by the pubo-rectales, and so completes the ano-rectal ring.

(iii) *Longitudinal muscle of the rectum.*—This becomes the longitudinal muscle of the anal canal. It encircles the internal sphincter and terminates in four ways.

1. As the recto-urethralis muscle attaching the rectum to the related structures in the midline anteriorly.

2. As the anal intermuscular septum attached to the junction of skin and mucosa of the anal canal and so producing the anal intermuscular depression.

3. As the corrugator cutis ani muscle running under and attached to the perianal skin.

FISTULA IN ANO

By E. T. C. MILLIGAN, O.B.E., M.D., F.R.C.S., F.R.A.C.S.
Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon, London

and

C. NAUNTON MORGAN, F.R.C.S.
Surgeon, St. Bartholomew's Hospital; Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon; Surgeon, Hospital for Tropical Diseases, London

and

O. V. LLOYD-DAVIES, M.S., F.R.C.S.
Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon, London

and

HENRY R. THOMPSON, F.R.C.S.
Assistant Surgeon, St. Mark's Hospital for Diseases of the Rectum and Colon, London

1. HISTORICAL

154.] *The cure of this condition was amongst the earliest of surgical problems,* and almost the first surgical treatise on the subject was written in England by John Arderne as long ago as 1376. In London, St. Mark's Hospital was founded by Frederick Salmon in 1835 with the object of evolving better treatment for this malady.

2. DEFINITION

Provided *the anatomy and physiology of the anal musculature* are understood and the method of healing of ano-rectal wounds is appreciated, there should be no reason for unsuccessful treatment.

deep and the subcutaneous parts of the external sphincter, but is unlike them in nerve supply, in its attachment to the coccyx and in being elliptical. It cannot be palpated separately.

(vii) *Anal intermuscular septum.*—The longitudinal muscle forms this septum by its main attachment to the anal canal lining, ½–¾ inch from the anal verge at the junction of the anal mucosa and the modified skin of the anal canal. The septum separates the subcutaneous portion of the external sphincter from the other muscles above it and produces the *anal intermuscular depression* which can be palpated. *Anal intermuscular depression*

(viii) *Levator ani muscle.*—The pubo-rectalis portion of the levator has already been described and its importance in control of defaecation mentioned; it remains to consider the pubo-coccygeus and the ileo-coccygeus portions.

Pubo-coccygeus muscle.—The pelvic diaphragm is formed in front by the pubo-coccygeus and more posteriorly, on an inferior plane, by the ilio-coccygeus. The pubo-coccygeus arises from the posterior surface of the pubis and the anterior part of the white line, and it lies at a higher level than the pubo-rectalis, which is regarded as being its specialized inferior and medial portion. It is inserted into the fibrous ano-coccygeal raphe lying above the insertion of the ilio-coccygeus. It embraces, but is not attached to, the rectum.

Ilio-coccygeus muscle.—This muscle arises from the ischial spine and the posterior part of the white line and is inserted into the ano-coccygeal raphe and coccyx. Its muscle fibres are often replaced by fibrous tissue and pass mainly downwards and inwards. It will be seen that the pubo-coccygeus passes backwards whereas the rest of the pelvic diaphragm runs downwards and inwards. These muscles, therefore, lie in different axes and on slightly different planes, the pubo-coccygeus being closely related to the lateral and posterior aspect of the rectal wall. Neither muscle has any part in anal control.

The whole of the inner and upper aspects of the various portions of the levator ani can easily be felt through the rectal wall, tightly stretched from their origins at the sides of the pelvis to their insertion; indeed, except for the rectal mucosa, they are the most prominent structures felt by the finger.

(2) Ischio-rectal fossa

This fossa is divided into two compartments by an outward extension of the longitudinal muscle. *Tw con*

(*a*) *The perianal space*

This subcutaneous space contains the subcutaneous external sphincter, the external haemorrhoidal plexus and finely granular fat. Although infection within it does not usually extend upwards into the ischio-rectal space, it may be involved in infection spreading from either the submucous or the ischio-rectal space.

(*b*) *The ischio-rectal space*

The ischio-rectal space is deep and capacious and loosely packed with large lobules of fat. It is related to the inferior aspect of the levator ani and to the superficial and deep external sphincter muscles. It extends anteriorly as far as the origin of the levator ani muscles from the pubis, passing deep to the

4. As a fibro-muscular transverse septum running outwards and dividing the ischio-rectal fossa into the subcutaneous perianal space and the more deeply placed ischio-rectal space (Fig. 35).

The longitudinal muscle is too thin to play any important part in rectal control but attaches the rectum to surrounding structures.

(iv) *Internal sphincter muscle of the anal canal.*—This is but the thickened termination of the circular coat of the rectum encircling the anal canal in its upper two-thirds and, in its turn, being encircled by the longitudinal muscle. The pubo-rectalis and the superficial and deep parts of the external sphincter muscle encircle them both. The internal sphincter muscle ends abruptly at the

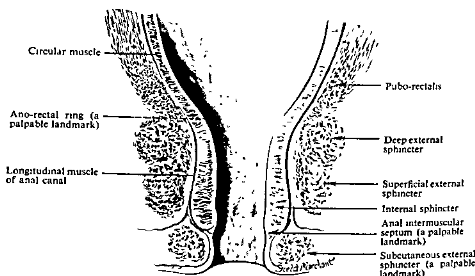


FIG. 35.—The muscles and palpable landmarks of the ano-rectal region.

anal intermuscular septum. It does not lie separately, as is often depicted in diagrams in which it has been mistaken for the ano-rectal ring. It plays a comparatively unimportant part in rectal control and is concerned only with postural tone: it can be disregarded in the operation for fistula in ano.

Importance of ano-rectal ring

Preservation of even a small portion of the ano-rectal ring will maintain control of normal faeces, whereas its *destruction produces incontinence.* It is, therefore, supremely important that this anatomical landmark should be identified with exactness by the examining finger in all operations for fistula in ano.

Posteriorly, the ano-rectal ring is felt producing a definite shelf and a right-angular curve between the rectum and the anal canal. Laterally, the shelf is less prominent and the curve or angle more obtuse.

Anteriorly, the ring is less well defined since it is only formed, as already shown, by the deep part of the external sphincter.

Relative unimportance

(v) *Subcutaneous external sphincter muscle.*—This is an annular muscle which has been likened to an umbrella ring ¼ inch in thickness. It surrounds the lower end of the anal canal and lies in the perianal space immediately beneath the skin of the anal margin, where its outline can often be seen. It can be palpated throughout its extent. Its division or loss is not important.

(vi) *Superficial external sphincter muscle.*—This muscle lies between the

to the superficial and deep external sphincters. It is in fact intramuscular (Fig. 37 (a) and (b)).

(3) Ano-rectal fistulae

The ano-rectal fistulae have an incidence of only 5 per cent. The main track extends above the level of the ano-rectal ring, but rarely opens into the bowel above this level. There is usually an internal opening into the anal canal, through the sphincter muscles, at a lower level (Fig. 37 (c), (d) and (e)).

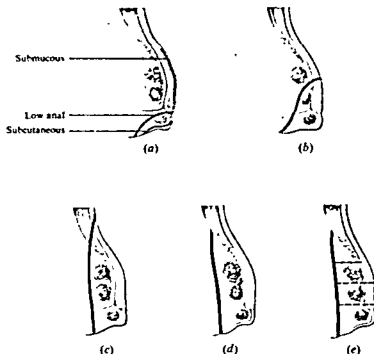


Fig. 37.—Classification of fistula in ano. Ano-rectal fistulae: (*a*) Submucous, low anal and subcutaneous fistulae; (*b*) high anal fistula; (*c*) ano-rectal fistula of very rare type; (*d*) ano-rectal fistula; (*e*) ano-rectal fistula with possible extension into bowel.

A light general anaesthetic should be used in all operations for fistulae which extend deeply, since it will be necessary to palpate the contracting ano-rectal ring constantly at operation. *Light general anaesthetic*

5. DIAGNOSIS AND TREATMENT

(1) Subcutaneous, submucous and anal fistulae

A submucous fistula may exist alone but is usually associated with a subcutaneous or anal fistula. Its indurated track may be felt under the mucosa in the anal canal, or it may be discovered with a probe during the operation. For its treatment division of muscle is not required but, because blood-vessels lie in its roof, division of the mucosa should be performed by means of a strangulating ligature passed through the track and not by cutting. *Control of bleeding*

The main track of both the subcutaneous and anal types of fistulae can be palpated under the perianal skin. The internal opening may also be felt near the intermuscular depression, but if not, the point of the probe, gently inserted along the main track from the external opening, will be palpated

transverse perineal muscles. Its outer wall is limited by the obturator fascia and the bony pelvis.

(*c*) *The supralevator space*

Infection rare

The supralevator space lies between the superior surface of the levator ani muscle and the rectal wall. Infection above the levator is not common; in our experience the large majority of high fistulae are not of the so-called pelvi-rectal type but are ano-rectal (Fig. 36).

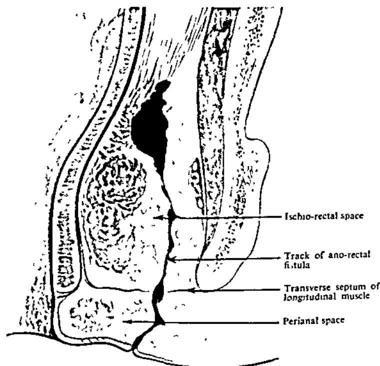


FIG. 36.—Ano-rectal fistula involving ischio-rectal and perianal spaces.

4. CLASSIFICATION

This classification is based upon the relationship of the main track to the anal musculature and to the landmarks already described, namely, the ano-rectal ring and the anal intermuscular depression. Most fistulae in ano follow a definite anatomical plan unless they are artificially produced.

(1) Subcutaneous and submucous fistulae

Occurring in 5 per cent of cases, these fistulae lie under the skin or mucous membrane and the track is not related to the sphincter muscles (Fig. 37 (a)).

(2) Anal fistulae

Low anal type

High anal type

The incidence of low anal fistulae is 75 per cent and that of high anal fistulae 15 per cent. These are fistulae in which the whole of the main track lies below the ano-rectal ring. In the *low anal* type, the track enters the anal canal at the anal intermuscular depression and is related to the subcutaneous external sphincter, whereas the *high anal* fistula enters anywhere between the ano-rectal ring above and the anal intermuscular depression below and is related

The external opening of the main track lies in the ischio-rectal fossa about 2 inches from the anus, whereas the external openings of the main track in

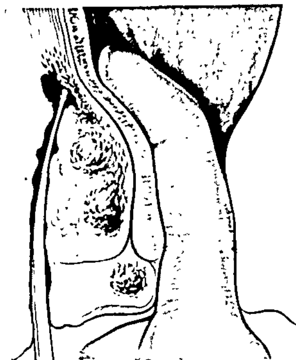


FIG. 41.—Ano-rectal fistula. Finger palpating induration and point of the probe above the ano-rectal ring.



FIG. 42.—Ano-rectal fistula showing parallel probe and depth of fistula.

other types of fistulae lie nearer the anus; this, however, is not invariably the case.

Parallel probe

The main track cannot be palpated under the skin, as in anal fistulae, but a probe in the main track passes upwards *parallel* with the anal canal. Only the point of the probe is felt through the rectal wall above the ano-rectal ring

Radial or transverse probe

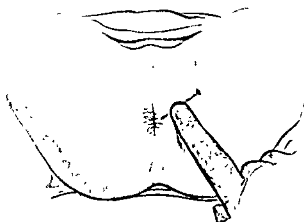


FIG. 38.—Anal fistula—finger is shown palpating *subcutaneous* induration.

under the lining of the anal canal at the intermuscular depression. It will be noticed that the probe will pass *radially* in the track towards the anal canal and that it lies transversely (Figs. 38, 39 and 40).

After a probe-pointed director is passed along the main track the latter is laid open. In the case of a subcutaneous fistula, muscle is not divided, but in the case of a low anal fistula the subcutaneous external sphincter ani muscle requires division.

The less common high anal fistula requires division of most of the external sphincter ani muscle, but not of the ano-rectal ring. This fistula extends amongst the muscle fibres of the external sphincter muscle and, therefore, is intramuscular.



FIG. 39.—Anal fistulae. Figure shows transverse probes in tracks.

After the main track is completely laid open to the skin surface, all subsidiary superficial extensions in the perianal space are similarly treated. Finally, skin is removed in order to form a flat wound radiating from the anal canal and so obtain healing by second intention.

Second-intention healing

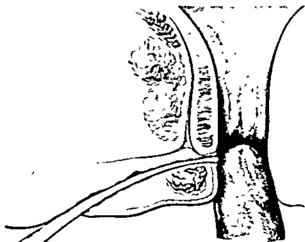


FIG. 40.—Anal fistula (low). Finger palpating end of probe at anal intermuscular depression.

(2) Ano-rectal fistulae

This type of fistula is comparatively uncommon and is responsible for the sinister reputation of fistula in ano. Its main track extends deeply into the ischio-rectal space above the level of the ano-rectal ring and reaches the inferior surface of the levator ani, when it extends along the surface of the puborectalis.

space related to these muscles may give to the examining finger the impression that the track is lying in the submucosa of the rectum. If, however, this were the case, the induration would extend downwards in this continuous submucosal space to below the ano-rectal ring into the anal canal (Fig. 45).

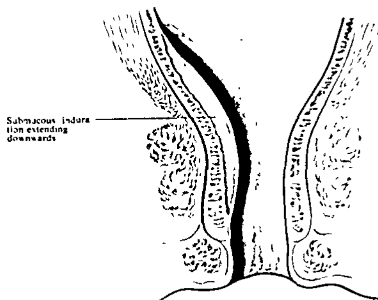


FIG. 45.—Demonstrating that infection in the submucous space will extend below the level of the ano-rectal ring into the anal canal.

Incision from within the lumen of the bowel into the induration in the ischio-rectal space would be disastrous, since an incurable fistula, with an internal opening above the ano-rectal ring, would have been produced.

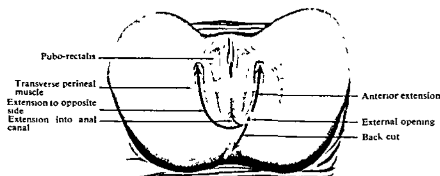


FIG. 46.—The plan of operative approach to an ano-rectal fistula.

An ano-rectal fistula therefore has: (a) *an anterior extension* running forwards and upwards along the pubo-rectalis muscle under the transverse perineal muscle towards the pubic ramus, and (b) *an extension to the opposite ischio-rectal space*, along the sling fibres of the pubo-rectalis muscle passing

Anterior extension

Extension to opposite ischio-rectal space

(Figs. 41 and 42). No induration is palpable in the anal canal, since the track lies in the ischio-rectal space external to the thick anal musculature. Extension along or amongst the fibres of the pubo-rectalis produces an induration

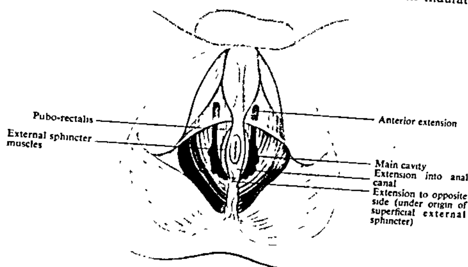


FIG. 43.—The pattern of an ano-rectal fistula showing relation of extensions to the muscles.



FIG. 44.—Ano-rectal fistula. Finger palpating extension to opposite ischio-rectal space above ano-rectal ring.

postero-laterally which can be felt through the rectum above or at the ano-rectal ring. Induration may be felt passing forwards towards the pubis and sometimes behind the rectum to the opposite side (Figs. 43 and 44).

Owing to the close relationship of the pubo-coccygeus and, especially, of its pubo-rectalis portion to the bowel wall, induration in the ischio-rectal

for safety. There may be a similar pattern of extensions, requiring similar treatment, on the opposite side (Fig. 46).

An extension into the anal canal is found with a fine probe, by palpation or by the presence of a minute dimple of granulation tissue. This extension must be shown to lie below the ano-rectal ring, so that overlying sphincter muscle can safely be divided. If no internal opening is found, the cavity is deliberately opened into the anal canal by identifying and dividing the subcutaneous external sphincter. This makes the deep wound shallower on its medial aspect and so reduces the time of healing.

The form of the wound

Formation of a classical flat wound, for the treatment of a fistula which extends deeply into the ischio-rectal fossa, is not anatomically possible. However, the wound is made as flat and shallow as possible, with shelving walls; this is effected by removal of fat and the skin covering the ischio-rectal fossa as the final stage of the operation.

(3) Dressings

Flat gauze dressings are laid on the wound from the floor of the cavity to the skin edges. In the case of an ano-rectal fistula, careful dressing, arranged to keep the cavity open and the wound surfaces apart, is of great importance.

6. AFTER-CARE

Initial dressings under anaesthesia

In anal fistulae the dressings are removed on the third day when the bowels act. Thereafter, the patient has daily baths followed by irrigation of the wound and application of a flat dressing. In the case of an ano-rectal fistula the dressings are removed under anaesthesia on the fifth day, the bowels being confined until then. Anaesthesia is necessary for the first few dressings in extensive fistulae. A careful watch is kept for undiscovered extensions, for bridging and for too rapid surface healing. This latter effect is most likely to occur in the anterior extensions, and it may be necessary to reopen this part of the wound during the process of healing (Fig. 47).

With extensive fistulae it is wise to warn the patient that, following the main operation, further anaesthesia may be necessary in order to dress the wound, to reshape it and, perhaps, to deal with a subsequently discovered pocket or extension. Final healing may take from 6 weeks to 6 months (Fig. 48). The management of these patients calls for constant care on the part of the surgeon and sustained trust on the part of the patient.

BIBLIOGRAPHY

Milligan, E. T. C. (1943). *Proc. R. Soc. Med.*, 36, 365.

— and Morgan, C. Naunton (1934). *Lancet*, 2, 1150, 1213.

Thompson, P. (1899). *The Myology of the Pelvic Floor.* London; McCorquodale.

[References to other titles are given under Fistula in Ano in the Index Volume. The subject is also dealt with under the heading of Anus Diseases in the *British Encyclopaedia of Medical Practice* (1936), Vol. 1, p. 643.]

behind the rectum. In addition to these two extensions there may be (c) *an extension into the anal canal* at any level below the ano-rectal ring, usually just below it (Figs. 37 (e) and 46). There may, however, be no internal opening; more commonly the opening is overlooked at operation, and is found only by careful and repeated search during the healing period.

Extension into anal canal

Unless all extensions are found and opened to the skin surface, complete healing will not occur, but if the surgeon has the pattern of these extensions in his mind they will be looked for and found with a probe at operation.

Details of operation

The main track, running parallel to the anal canal, is first laid open by cutting directly backwards from the inlying parallel probe to the level of the coccyx through the skin and fat of the fossa. The bowel is guarded by a finger, which is placed in the anal canal, whilst this deep *backward* cut is being made. The superficially-lying coccyx is in the same horizontal plane as the deep part of the cavity since the levator muscles are inserted here; thus, by this backward cut, the depths of the cavity are exposed. This is the first stage in procuring a relatively shallow wound.

Deep backward cut

The edges of this wound are retracted, the main cavity is examined, and extensions are sought with a probe. Removal of granulation tissue by curettage exposes the fibrous walls; pockets and extensions are then made visible.

The *anterior extension* is now laid open by cutting forwards along the inserted probe-director, a finger guarding the rectal wall and ano-rectal ring meanwhile. The transverse perineal muscle will be divided.

Extension to the opposite ischio-rectal space behind the rectum is searched for and, when found, is laid open, with the guidance of a finger in the rectum

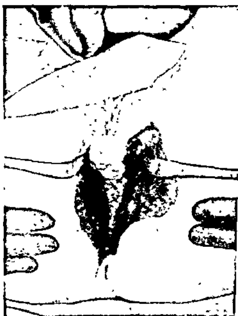


FIG. 47.—Ano-rectal fistula (as in Fig. 46). Surgical wound resulting from "opening up" of all tracks.



FIG. 48.—Ano-rectal fistula (as in Fig. 46). The fistula is almost healed showing resulting scars.

TABLE I
CAUSES OF EPILEPSY AT VARIOUS AGES

Age at Onset of Seizures: Years		Presumptive Cause
Infancy	0–2	Birth injury Congenital abnormality
Childhood	2–10	Birth injury Febrile thrombosis Trauma Cryptogenic
Adolescence	10–20	Cryptogenic Trauma
Youth	20–25	Trauma Neoplasm
Middle age	35–55	Neoplasm Trauma Arteriosclerosis
Senescence	55–?	Arteriosclerosis Neoplasm

double that figure after severe brain wounds (Wagstaffe, 1928; Ascroft, 1941; Cairns, 1942; Gliddon, 1943; Penfield and Shaver, 1945).

Slowly growing neoplasms more often produce symptomatic epilepsy than rapidly growing varieties, and they more often have seizures for the first symptom. Brain abscesses are apt to be associated with seizures at an early stage and again later after successful treatment and formation of scar. Subdural haematomas have a relatively low incidence of secondary epilepsy unless the patient also received a cerebral laceration (Penfield, Erickson and Tarlov, 1940). *Brain tumours and abscesses*

3. SURGICAL ANATOMY

(1) Craniocerebral topography

Areas of the cerebral cortex are shown in relation to the overlying cranial structures in Fig. 49. It must be borne in mind that an expanding lesion displaces structures away from itself; also that an atrophic lesion, acquired early in life, produces displacement of cerebral structures towards itself.

(2) Cerebral Cortex

The removal of completely normal cortex is very rarely advisable, but when a diseased area is to be excised, the neurosurgeon must often venture a considerable distance into partly normal, or normal-appearing, cortex. Any area of grey matter on the convexity of the hemispheres can be removed without loss of life or consciousness. Neurosurgeons have learned that the vital regions of the brain lie in the diencephalon about the third ventricle and in the brain stem.

No removal of any part of the brain should be undertaken lightly, although in large areas the defect may be difficult to discover. For example, a major portion of one frontal lobe may be removed with only a reduction in the patient's capacity for planned initiative, a defect difficult to demonstrate by ordinary methods of examination. *Cortical excision*

FOCAL EPILEPSY

By WILDER PENFIELD, C.M.G., D.Sc., M.D., F.R.C.S., F.R.S.
PROFESSOR OF NEUROLOGY AND NEUROSURGERY, MCGILL UNIVERSITY; DIRECTOR, MONTREAL NEUROLOGICAL INSTITUTE; SURGEON, ROYAL VICTORIA AND MONTREAL GENERAL HOSPITALS

1. DEFINITION

155.] Epilepsy is the tendency to recurring epileptic seizures. An epileptic seizure is the state produced by an excessive neuronal discharge within the central nervous system. The term focal epilepsy may be applied to those cases in which each attack begins with discharge in the vicinity of a demonstrably abnormal focus.

2. AETIOLOGY

The irritative condition which results in these discharges may be produced by a variety of causes, as indicated in Table I. This led Hughlings Jackson to refer to "the epilepsies", and to classify them according to cause. A certain large group, in which the disability is sometimes familial, must be classified as cryptogenic (κρυπτός=hidden). The term idiopathic, or essential, is also used to refer to this group. In such patients no specific cerebral lesion has been described. The same is true, of course, for the seizures produced by extracranial influences such as hypoglycaemia, also toxic and febrile conditions.

Cryptogenic group and extracranial causes

Any head injury, regardless of severity, that is associated with penetration of the dura and cerebral laceration, may be followed by post-traumatic epilepsy. The incidence has been estimated at 18 to 20 per cent, but it is probably

Post-traumatic epilepsy

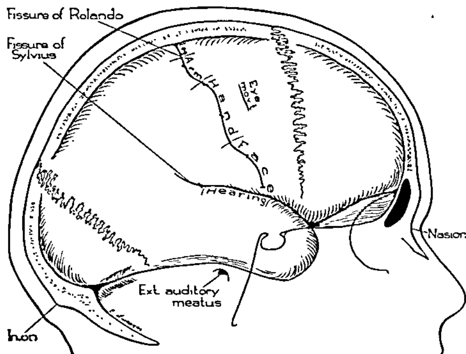


FIG. 49.—Topography of skull and brain, lateral projection. Preparation of the outline was as follows: at operation tantalum clips were placed in the central and Sylvian fissures and the extent of leg, arm, hand and face was charted by stimulation, also eye movement and hearing. A post-operative lateral skiagram was made showing the clips superimposed on cranial outlines.

Pre-central gyrus

In Fig. 50 the shaded areas indicate the regions which should be avoided during excision. It does not seem a justifiable procedure to produce permanent paralysis in the uncertain hope of arresting epileptic seizures. Pre-central gyrus for arm and leg should therefore be carefully avoided on both sides.

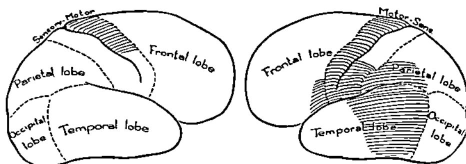


FIG. 50.—Cerebral hemispheres, right and left, to show division into lobes and regions. The shaded areas are not to be removed except under special circumstances. The additional areas of shading on the left (dominant) hemisphere are considered indispensable for normal speech. Unshaded areas are considered dispensable.

Lower Rolandic cortex

On the non-dominant side, if the demarcation between upper face and thumb is outlined by stimulation, the pre-central and post-central gyri may be removed completely from that point down to the bottom of the fissure of Sylvius with impunity, inasmuch as face and mouth have a bilateral representation.

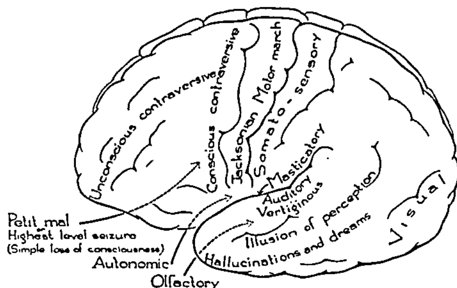


FIG. 52.—Areas of origin of different types of epileptic seizures. The highest-level seizure and the autonomic seizure take origin near the midline, the olfactory seizure beneath the temporal lobe.

be produced under observation by withdrawal of medication, by hyperpnoea, or by hydration.

Although seizure pattern is more important and more reliable than any other diagnostic aid, limitation of space prohibits extended description here. The enumeration in Table III will have to suffice. In Fig. 52 the areas of cortex in which these seizures arise are indicated. True Jacksonian motor march is

TABLE III

SEIZURE PATTERNS

	INITIAL PHENOMENON	LOCALIZATION
Motor	Jacksonian (movement in extremity or face)	Pre-central gyrus
	Masticatory (movement in throat or mouth)	Lowest pre-central
	Unconscious contraversive	Anterior frontal
	Conscious contraversive (without sensory aura)	Posterior frontal
Sensory	Somato-sensory (extremity, face, mouth, thirst)	Post-central gyrus
	Visual (moving lights)	Occipital
	Auditory	Temporal (margin fissure Sylvius)
	Vertiginous	Temporal (margin fissure Sylvius)
	Olfactory	Infra-temporal (uncinate)
Visceral	Autonomic	Diencephalon
Psychical	Dreamy state (a: perceptual illusion, b: hallucination)	Temporal
	Petit mal (simple lapse of consciousness)	(?) Inter-hemispheral
	Automatism { ictal, post-ictal	Usually frontal Often following masticatory or olfactory seizures
	Psychotic states (secondary to status epilepticus)	

Local atrophy

Brain injuries of all types produce destruction of neurones. Ganglionic regeneration never occurs, but unless the destruction is complete the neuroglia reacts in a positive manner, producing gliosis. With all destructive processes active phagocytosis occurs, and this results in gross atrophy of involved convolutions.

Meningo-cerebral scar

If there has been laceration of the cortex, connective tissue and glial tissue come to be intermingled in a contracting scar, as shown in Fig. 51(A). Ganglion cells disappear in the centre of the scar. Compression (Fig. 51(B)) and ischaemia produce atrophy without the appearance of glial-connective-tissue scar.

TABLE II

TYPES AND CAUSES OF EPILEPTOGENIC LESIONS

LESION	PRODUCED BY
Cerebral cicatrix	Previous trauma Infection
Local cerebral atrophy	Previous compression Ischaemia, etc.
Local microgyria	Previous infantile compression Ischaemia
Expanding lesion	Tumour Abscess, etc.
Cysts and abnormalities	Congenital defect Vascular changes

Microgyria

The production of local microgyria is probably as follows: one or more gyri are partly destroyed by ischaemia or local compression at the time of birth. The neighbouring normal gyri then are crowded in towards the shrivelling gyri during the process of brain growth (Fig. 51(C)).

Cyst

Vascular occlusion may destroy an area of cortex and thus form a cyst. Such cysts are at times covered with translucent grey matter (Fig. 51(D)).

By the time habitual seizures develop, all the various types of lesion seem to present one common feature. This common feature is an area of grey matter in which destruction is only partial (note arrows in Fig. 51), and in which histological study demonstrates that destruction is very slowly progressing, even years after the initial insult. It is in such areas of grey matter that the epileptogenic focus is found.

Epileptogenic focus

5. CLINICAL PICTURE

(1) Cause of attacks

Age of onset

From a practical point of view the age of initial onset of seizures allows a clinician to make a presumptive diagnosis of the attacks, a diagnosis which he must then attempt to verify or disprove. In Table I some common causes are placed in order of likelihood at each age level.

(2) Seizure patterns

The most important clue to localization of an epileptogenic lesion is the pattern of attack. Any seizure may develop into a generalized convulsive attack. Therefore, it is the minor seizures or the initial phase of a major attack which must be analysed. If adequate description is not forthcoming, attacks should

Initial phenomenon

apt to follow the topical localization shown in Fig. 53, and the somatosensory topical representation is also recorded there.

It may be added that the epigastric aura and the abdominal aura, which are midline sensations, usually seem to have a localization near the island of Reil, but when one of these auras is present as an initial phenomenon, the *Epigastric aura*



FIG. 55.—Hemiatrophy of skull. Sagittal suture is about 1 centimetre to left of the expected mid-sagittal plane. Note elevation and enlargement of left frontal sinus, also elevation of the left petrous ridge; the mastoid antrum is larger and better aerated on the left than on the right. Oxygen in the ventricles shows the septum pellucidum to be deviated to the left and the body of the left ventricle to be enlarged.

prognosis for success of surgical therapy is doubtful in the present state of our knowledge.

Salivation seems to have a localization in the post-central region deep in the central fissure and extending down to, and possibly into, the island of Reil. It is usually associated with a masticatory seizure. Complete excision of mouth and throat areas on the side of discharge is advisable. *Salivation*

6. SPECIAL AIDS TO DIAGNOSIS OF ATROPHIC LESIONS

Special diagnostic techniques have introduced great accuracy into cerebral localization, but no diagnostic aid should be followed blindly. In the end, the neurosurgeon who contemplates radical operation must himself make a

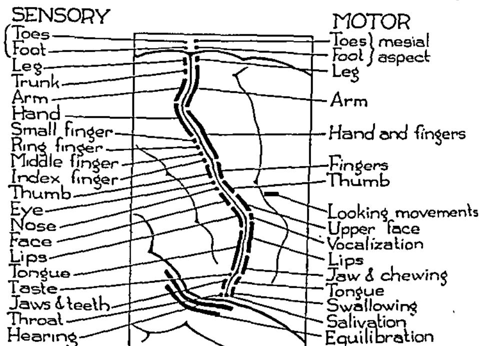


FIG. 53.—Sensori-motor representation posterior and anterior to the fissure of Rolando. Hearing and equilibration are shown below the fissure of Sylvius. Length of the band indicates only approximate extent of representation. The actual antero-posterior representation extends from the bottom of the central fissure over the whole extent of the pre-central and post-central convolutions.

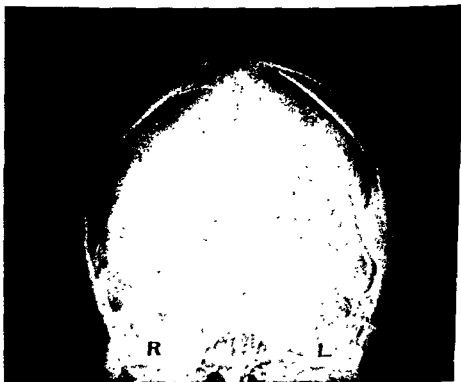


FIG. 54.—Depressed fracture of skull. This right-handed man received a blow from a rifle in the left posterior temporal region 2 years previously. He was unconscious for 30 minutes but returned to duty next day. Same patient as in Figs. 59 and 60.

and even the mastoid air cells may be larger on that side, as though endeavouring to hide the evidence of the cerebral defect (Fig. 55). *Sinus enlargement*

(2) Pneumoencephalography

Lumbar injection of oxygen should be used to demonstrate the ventricular outlines and sometimes superficial abnormalities. Meningo-cerebral scars, *Oxygen injection*







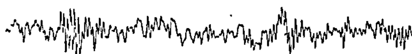


FIG. 57.—Forms of electroencephalographic disturbance in epileptogenic lesions of the cortex, records being taken from scalp leads. (1) The random spikes are the most reliable indication of focal epileptic discharge from a superficial cortical lesion. (2) Sharp waves may represent a conducted disturbance from a spike focus in cortical regions inaccessible to electrodes over the convexity. (3) Slow waves are non-specific signs of cortical damage, and are not considered adequate evidence of an epileptogenic lesion. (4) Multiple spikes are occasionally the only electrographic disturbance from certain more extensive epileptogenic lesions (such as larger areas of cerebral contusion from depressed skull fracture). The random, arrhythmic sequence of these disturbances and their precise and consistent localization on repeated examinations are important diagnostic features. (*Figure and legend by courtesy of Dr. Herbert Jasper.*)

especially when secondary to severe brain laceration, give rise to local enlargement of the underlying ventricle, and there is apt to be displacement of the whole ventricular system towards the side of the lesion, as shown in Fig. 56 (Foerster and Penfield, 1930a).

balanced judgement of the evidence before him: epileptic pattern, electro-encephalogram, cortical stimulation, pneumoencephalogram, history, neurological status, and the patient's personal problem. Much hangs in the balance.

(1) Radiography

Skull fracture

Depressed fracture of the skull is demonstrable long after the injury (Fig. 54). Cranial erosion may occur, particularly in the vicinity of a severe skull fracture, as an evidence of local absence of the dura mater. When the

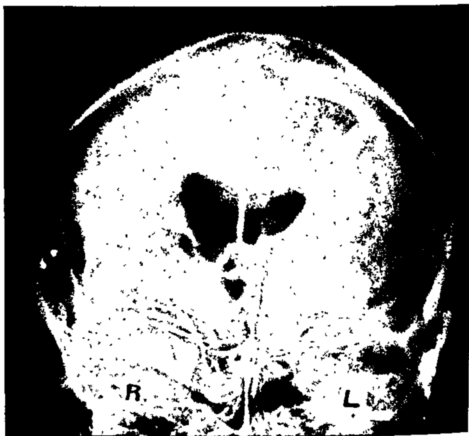


FIG. 56.—Wandering of ventricular system toward meningo-cerebral scar. Gunshot wound of brain; cerebral abscess treated successfully. Nine years later onset of focal epilepsy of masticatory type; excision of temporal lobe with scars and foreign bodies.

inner surface of the bone is examined at operation, it is seen that the inner table is irregularly eroded and thickened (Fig. 59), as though the uncovered cerebral tissue were capable of exerting an irritating influence upon the bare bone.

Cranial hemiatrophy

During childhood, the gradual enlargement of the skull depends upon the outward thrust of the growing brain. Consequently, comparative smallness of one lateral cranial chamber, as seen in an antero-posterior skiagram (Fig. 55), should be considered as suggestive evidence of injury to the smaller hemisphere in infancy. Dyke (1936) pointed out that the skull on the small side may show increased density, and it is usually true that the frontal sinuses

brain this very rarely happens. On the contrary, seizures due to a scar or an atrophic focus tend to occur with gradually increasing frequency as the years pass.

When the cause is cerebral neoplasm, the attacks sometimes increase even more rapidly in frequency and severity regardless of medication. After complete removal of a neoplasm, the attacks continue in about half of the cases,

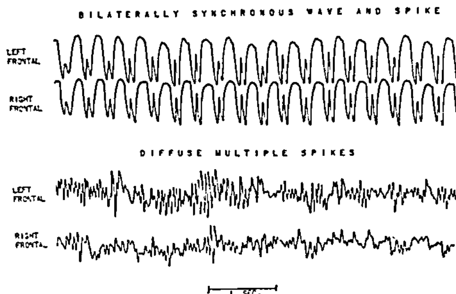


FIG. 58.—Forms of electroencephalographic disturbance in generalized or cryptogenic epilepsy. The bilaterally synchronous wave and spike pattern is most common in patients with seizures (often *petit mal*) beginning in childhood or adolescence, frequently with a genetic background. Absence of consistent unilateral cortical localization is an important diagnostic feature of the electroencephalogram in these patients.

but the frequency is apt to decrease during the year or two which follow operation, and, if the neoplasm was encapsulated, they may disappear completely with adequate medical therapy (Penfield, Erickson and Tarlov, 1940).

9. INDICATIONS FOR SURGICAL INTERVENTION

When conservative therapy is not sufficient to enable an epileptic to lead a reasonably normal life, and if his electroencephalogram is not specifically that of cryptogenic epilepsy, then radical therapy should be considered. With that possibility in mind, he should be studied carefully. Operation is to be embarked upon if an objective lesion and an electrographic disturbance are demonstrated in such a cortical area as to correspond with the seizure pattern.

Cranioplasty

When head injury has produced a cranial defect, this may be closed without disturbing the dura or scar tissue that covers the cerebrum. Such cranioplastic procedures alone should be undertaken only for the patient's safety, or if the cosmetic effect is urgently desired, or, finally, to relieve headache and dizziness which seem to be due to the defect.

Cerebral arterial or venous occlusion results in ipsilateral ventricular enlargement, or in cerebral cyst formation.

Infantile microgyria, when associated with cranial hemiatrophy, may be present with little or no ventricular enlargement.

Closed cysts within the brain are often not detected by pneumoencephalography. Calcification of various atrophic lesions of the brain is too obvious to require description in this brief report. Certain vascular neoplasms and arteriovenous aneurysms may give evidence both of expansion and of local atrophy.

Arteriography Arteriography should be used in the study of such cases.

(3) Electroencephalography

When Berger (1929), followed by Adrian, Davis, Kornmüller, Jasper, Gibbs, Walters, Williams, Lennox and others, began to record the spontaneous electrical activity of the brain, a new chapter in the localization of epileptic discharge was opened. In traumatic epilepsy, if proper localization technique is employed, and if the patient is studied over an adequate period of time, evidence of localized epileptiform dysrhythmia (Fig. 57) in a relatively restricted area of one hemisphere may be obtained in 90 per cent of patients (Jasper and Penfield, 1943). In about 70 per cent of such patients a comparatively superficial focus, where "spike" or sharp wave discharges occur, may be demonstrated without significant complication of abnormality elsewhere in the brain. A direct electrocorticogram may be of great help after the brain is exposed at the time of operation.

Spike and sharp wave localization

7. DIFFERENTIAL DIAGNOSIS

Reasonable familiarity with the nature of epileptic seizures renders differentiation of these attacks from syncope and hysteria a simple matter. The most important problem in differential diagnosis is to distinguish symptomatic epilepsy from cryptogenic epilepsy.

Cryptogenic epilepsy

Idiopathic, or cryptogenic, epilepsy usually first makes its appearance within a few years of puberty. The minor (*petit mal*) seizures are apt to be characterized by an unheralded lapse of consciousness, with or without falling. The major seizures are generalized convulsions which usually occur without turning or lateralization of convulsive movements, and without sensory or psychical aura. There is often evidence of a family tendency to epileptic seizures.

The electroencephalogram gives a record almost pathognomonic of cryptogenic epilepsy. There is a bilaterally synchronous 3-per-second discharge, usually of spike and slow wave form (Fig. 58), and most often frontal in location. The disturbance is increased by hyperventilation. This type of record is never seen in symptomatic epilepsy except perhaps when a lesion is placed underneath one frontal lobe or between the frontal lobes.

When seizures are associated with some diffuse cerebral abnormality or degeneration, the electroencephalogram also gives a characteristic record (Fig. 58).

8. PROGNOSIS

In cryptogenic epilepsy the attacks may stop spontaneously, but in cases of symptomatic epilepsy in which attacks are due to an objective lesion within the



FIG. 59 —Operation photograph. Depressed fracture of the skull; same patient as in Figs. 54 and 60. Note erosion of inner surface of skull where it lay over the defect in the dura.

cerebral cortex has been exposed widely (Fig. 60(b)), the surgeon is faced with the necessity of discovering the epileptogenic focus. As has already been emphasized, it is apt to be in a partly destroyed gyrus or, it may be, a group of small atrophic gyri.

Electrical stimulation

Electrical stimulation, as described in the next section, should now be employed to outline the sensory and motor convolutions, for they cannot be recognized by inspection alone. After that, if the patient has an habitual aura

Meningo-cerebral adhesions

Neither cranioplasty nor separation of adhesions that have formed between dura and brain is of any value in preventing or relieving epilepsy. The surgeon who opens the dura should be prepared to deal radically with the abnormality that lies within the brain.

10. PRE-OPERATIVE MANAGEMENT OF THE PATIENT

Conservative therapy

It is well to teach the patient to follow a proper anti-convulsive régime pre-operatively in every case. He should be warned against constipation, and he *should forgo the use of alcohol in any form. He should learn to reduce* his total fluid intake to a minimum, and he should take faithfully the anti-convulsive medication which may be prescribed for him. If this is adequate to control seizures reasonably well, it is best to postpone consideration of operation indefinitely. Any patient who refuses to follow the physician's conservative régime is not a fit subject for operation.

Psychological preparation

The surgeon who plans exploration and cortical excision under local anaesthesia *should take time to make friends with his patient,* so that the latter understands the aims of the operator and desires to undergo the ordeal. This is especially necessary in the case of children.

Before the operation do not starve or purge the patient. Give him, by the mouth, fluid high in protein and in readily digestible carbohydrate 3–5 hours before operation. *Discontinue all anti-convulsive medication* except phenobarbitone several days before operation. Use just enough of this drug so that he is not apt to have major spontaneous seizures during the procedure. Clip and shave the hair as necessary the morning of operation.

11. OPERATIVE TECHNIQUE

Local analgesia

Operative technique changes constantly, and those details which seem essential to success today may be modified tomorrow. Local analgesia is usually preferable to a general anaesthetic, for it makes possible cortical stimulation, *electrocorticography, and discussion with the patient* in case an aura is produced. Give no pre-operative sedative and nothing more than codeine during the procedure. For an adult, Nupercaine (1 : 1,500) 125 cubic centimetres, and (1 : 4,000) 125 cubic centimetres should provide analgesia for 6 to 7 hours if adrenaline is added to the solutions. When closure of the wound is begun, *it has been our custom to allow the patient to sleep* with the help of Avertin by rectum or Pentothal Sodium intravenously.

(1) *Osteoplastic craniotomy*

An osteoplastic flap is turned down, leaving a minimal attachment of bone to epicranium (Fig. 59). In case there is a defect in the skull, the scalp should be turned down separately, leaving the pericranium and temporal muscle behind. Then an incision is made in the pericranium at the margin of the skull defect, and *the bone is freed from the dura and scar all around* the opening. The bone flap can then be cut with burr, trephine, and Gigli saw, and turned down on its pericranial attachment without pulling on the brain scar.

The dura should be opened and reflected carefully, cutting any adhesions that may be present *so as not to injure the brain* (Fig. 60(a)). Once the

for the cortex is apt to become refractory to further stimulation and the patient may become unmanageable.

Excision — Excision must be clean, leaving behind little or no cerebral tissue that is not viable. The removal is restricted to the grey matter extending into white matter as short a distance as possible. In doing this a sucker of small bore (2 millimetres) and convenient length (10 centimetres) is of great assistance.

Ventricle opening — Care should be taken not to open the ventricle. Foerster and Penfield (1930b) made a habit of leaving it open, but we have gradually realized that to do so renders the patient liable to post-operative aseptic leptomeningitis as the result of serum that may continue to pass into the ventricles and out into the basal subarachnoid cisterns during the weeks after operation (Finlayson and Penfield, 1941). The ependymal lining of the ventricle is tough and can usually be spared by the surgeon; or it can be closed with loosely tied sutures, if necessary.

Criteria for excision — How large or how small to make an excision must always be a problem difficult to decide, and on its solution depends the success of the procedure. Not all abnormal brain can or should be removed. The essential criteria for removal are: appearance of the cortex, knowledge of the initial phenomenon in the patient's seizure, and the exact knowledge of the cortical structures which can only be gained by cortical stimulation. The electrographic studies, the pathological hypothesis and the clinical picture form the essential background against which decision must be made.

Dural closure — The dura should be closed at the end of the procedure. The edges of the dura should be fastened up to the pericranium at several points by silk sutures, as shown in Fig. 59. In case of extradural post-operative bleeding, this prevents stripping of the dura from the undersurface of the cranium.

Replacement of bone flap — When the bone flap is replaced, it may be fastened in place with one or two tantalum or steel wires, and the burr holes closed for cosmetic purposes with a bone button or a tantalum disc. If there is a defect in the bone flap, it may be closed with a perforated tantalum plate that has been hammered to the contour of the skull. The plate should be fastened firmly to the edges of the bone defect with tantalum wire. *Cranioplasty*

Scalp closure — The scalp incision is closed in two layers after the technique of Cushing. A rubber drain, if one is to be used, is brought out through a "stab wound" adjacent to the incision. Cerebrospinal fluid will thus bathe the dressing. The innermost gauze should therefore be covered by a protective tissue (rubber, oiled silk, or plastic) which covers the gauze and rests on the sterile scalp all around. It is well to place sterilized Vaseline on the skin in this peripheral zone. This drain allows fluid, trapped air, and blood to escape along the drainage tract. The fluid then finds its way out under the protective tissue and is absorbed into a larger sterile dressing that has been placed over the head. The drain is removed and the "stab wound" closed at the end of 24 to 48 hours. *Dressing*

(2) Cortical stimulation

Sensori-motor — In order to outline the sensori-motor area, a bipolar (or unipolar) electrode may be used. The electrical current should have a frequency of about 60 per second and a voltage of from $\frac{1}{2}$ to 2. For other areas the voltage may be gradually increased up to 3 or even 6 volts. The human brain seems to vary



FIG. 60.—Same patient as in Figs. 54 and 59. (a) Reflection of dura. (b) Scar in brain. Seizures began 6 months before operation. Dotted black line indicates central fissure above and fissure of Sylvius below. Stimulation at 2 caused the patient to make a movement of the lips and slight vocalization; at 4, "tickling" of right upper lip. Electrocorticogram gave "spike" discharge at A only. Removal was small because of fear of aphasia and was carried out along the dotted white line. Result excellent.

that precedes major attacks, or constitutes minor ones, an effort should be made to reproduce it by stimulation. Nothing is to be gained by using a current strong enough to induce a major seizure, and much may be lost thereby,

missed. Further removal was followed by complete cessation of attacks during the 7 years that have elapsed since operation.

13. RESULTS OF TREATMENT

All patients who had craniotomy because of epileptic seizures during a ten-year period were analysed. Electroencephalography was not available during the first half of this period. There were 165 patients in the series, and the total operative mortality was 4·2 per cent. Of the 62 patients who had excision of a meningo-cerebral lesion, 22·5 per cent never had a seizure again, 22·5 per cent were "75 per cent cured", one attack being enough to drop a patient to this group. Thirty-two per cent of these patients were "50 per cent improved" and 2 per cent were worse off after operation. Of the 53 patients who had excision of a cerebral lesion without meningeal involvement, the corresponding percentages were 19 per cent, 21 per cent, 10 per cent and 2 per cent.

When each post-operative year was analysed separately, it was found that, on an average, 45 per cent of all the patients were free of all attacks during the year. The total patients who considered themselves definitely improved by operation was 78 per cent in the first year, rising to 86 per cent in the fourth year and dropping to 70 per cent in the ninth year.

In 35 cases, craniotomy was carried out without sufficient localization to justify excision. If this be considered a control group, it may be pointed out that only one (or 2·5 per cent) had no further attacks. In 69 per cent there was no change, and in 6 per cent the attacks became more frequent.

REFERENCES

Ascroft, P. B. (1941). *Brit. med. J.*, **1**, 739.
Berger, H. (1929). *Arch. Psychiat. Nervenkr.*, **87**, 527.
Cairns, H. (1942). *War Med.*, **2**, 772.
Dyke, C. G. (1936). *Diagnostic Roentgenology*, ed. by R. Golden, p. 1. New York; Nelson.
Finlayson, A. I., and Penfield, W. (1941). *Arch. Neurol. Psychiat., Chicago*, **46**, 250.
Foerster, O., and Penfield, W. (1930a). *Brain*, **53**, 99.
— — (1930b). *Z. ges. Neurol. Psychiat.*, **125**, 475.
Gliddon, W. O. (1943). *Canad. med. Ass. J.*, **49**, 373.
Jasper, H., and Penfield, W. (1943). *Amer. J. Psychiat.*, **100**, 365.
Penfield, W., and Boldrey, E. (1939). *Amer. J. Psychiat.*, **96**, 255.
— and Erickson, T. G. (1941). *Epilepsy and Cerebral Localization*. Springfield, Ill.; Thomas.
— — and Tarlov, I. (1940). *Arch. Neurol. Psychiat., Chicago*, **44**, 300.
— and Shaver, M. (1945). *Res. Publ. Ass. nerv. ment. Dis.*, **24**, 620.
Wagstaffe, W. W. (1928). *Lancet*, **2**, 861.

[References to other titles are given under Focal Epilepsy in the Index Volume. The subject of Epilepsy is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 96.]

greatly in responsiveness. One part may be refractory all through the exploration, but a point which gives response will give the same response when repeated later; or, if not, the localization should be disregarded. Points should be marked with small paper cards. It is well to tell the patient each time the stimulation is applied, but his reliability as a witness must be checked by occasional stimulation without announcement and occasional announcement without stimulation.

Distant response

In general, recurring seizures seem to have a conditioning effect upon the cortex so as to make it locally more responsive to stimulation. Occasionally the neurosurgeon will encounter the phenomenon of distant response (Penfield and Boldrey, 1939). Over a wide area a somatic sensory response or a motor response in the face may be produced, but not motor for the extremities. Such distant response is not necessarily a part of the habitual seizures. Regardless of the usual seizure pattern, it is ordinarily easy to produce a sensation of sound by stimulating the auditory zone in the first temporal convolution, and to produce a sensation of lights from the occipital areas. It is usually possible to reproduce an illusion of perception or a part of an hallucination from various points in the temporal lobe, provided these constitute the habitual onset of the patient's seizures; but anterior to the motor cortex stimulation is of little or no use. With the type of current now in use typical fits do not result from stimulation here.

Dreamy state

(3) Electrocorticography

Electro-corticogram

Electrocorticography during operation may be of help to localize the epileptogenic zone. Non-polarizable electrodes on flexible wires are attached to a holder and applied to the cortex in various positions. If there is a meningo-cerebral scar, it is best to carry out the survey on the outer surface of the dura so that the trauma of opening does not alter the electrical state of the cortex. Otherwise the electrodes are applied directly to the cortex.

12. POST-OPERATIVE CARE

During the first 5 days, patients should be carefully nursed. The dressing is usually off at the end of a week and the patient out of hospital at the end of 2 to 4 weeks. *Phenobarbitone should be given immediately after operation*, and it is our custom to continue this for a year or two in decreasing dosage. All medication may be withdrawn for a few days before the patient leaves hospital so that a post-operative electroencephalogram may be recorded.

In case there are seizures within the first few days which have the same initial pattern as before operation, it is likely the procedure has failed. It is sometimes wise then to reopen the wound and carry out a little further excision. Such reopening should be done either before the tenth day or after a lapse of months.

For example, in one case an effort had been made to remove all of the cortex in which face and throat were represented in the right hemisphere. After operation the young woman continued to have her habitual seizures which began by salivation and puckering of the mouth. She was subjected to re-operation on the eighth post-operative day and it was found that an area of grey matter, from which stimulation still produced salivation, had been

PART V

HALLUX VALGUS

PART VI

HALLUX RIGIDUS

PART VII

PARALYTIC DEFORMITIES OF THE FOOT

PART VIII

MINOR SURGERY OF THE FOOT

FOOT—SURGERY OF

By T. T. STAMM, F.R.C.S.
Orthopaedic Surgeon, Guy's Hospital, London

PART I
FOOT STRAIN

PART II
ANTERIOR FOOT STRAIN

PART III
PES CAVUS AND CLAW TOES

PART IV
CLUB-FOOT

is in contact with the ground, there can be no tension on any ligamentous structures, the work of the muscles will be reduced to a minimum, and so fatigue and foot strain will be obviated.

In order that the foot may make proper contact with uneven surfaces, it must also be supple. In fact, the more supple the foot the less the likelihood of any of its ligamentous structures being under strain.

It follows from what has been said that a foot which is both flat and supple is best adapted to serve as a pedestal.

As a lever

(2) In the movements of walking, running, jumping and so on, the foot is required to act as a lever, and the essential feature of an effective lever is that it should be rigid. The foot, however, is composed of a number of movable segments and it can only be held rigid under strain if it adopts the form of an arch. The relaxed, flattened foot of the resting position is first converted into its fully arched form and then held rigidly in that posture by muscular action. The principal muscles concerned in maintaining the longitudinal arch of the foot are the tibialis posterior and the peroneus longus (which act as a sling under the arch), and the short muscles of the sole of the foot (which brace together the bases of the arch).

The ideal foot

The essential features of the ideal foot, therefore, are that it should be supple, flat when standing at rest, but arched during activity and well controlled by healthy muscles.

The foot of the average adult does not flatten completely when standing at rest and, in order to avoid strain upon its ligaments, it requires continuous support from its muscles. On this account, it is prone to fatigue and foot strain, especially after long periods of standing—a posture even more tiring to the muscles than walking because they are then alternately contracting and relaxing.

Feet that are stiff or too highly arched are the most liable to foot strain, whereas the supple, flat foot, although inefficient as a propelling mechanism, never develops the condition.

Certain other factors, outside the foot itself, predispose the foot to strain :

"Short tendo Achillis"

(1) "Short tendo Achillis." This inaccurate term is used for convenience to describe a condition, present in many individuals, in which the normal total length of the calf muscles is too short to permit the foot to be dorsiflexed to a right angle at the ankle joint. In this condition the heel can make contact with the ground only if the foot is everted, for this movement at the subtalar joint is accompanied by a limited amount of dorsiflexion. As a result, when standing, the foot is rolled over into the valgus position, and the body-weight transmitted to its medial border. In this position the longitudinal arch is obscured and the foot appears to be flat. When it is examined off the ground, however, it will be found that the longitudinal arch is in fact normal, or even higher than normal. The individual is standing flat-footed, but he has not got a flat foot. It is this condition which is responsible for the common fallacy that "flat-foot" is a cause of foot strain.

Valgus foot strain

The symptoms of strain which develop as a result of this valgus attitude of the foot are recognized clinically under the term "valgus foot strain", secondary to "short tendo Achillis".

Deformities of the leg

(2) Any deformity of the leg, such as genu valgum, is also liable to throw the foot off its proper balance and so predispose to foot strain.

PART I
FOOT STRAIN

1. DEFINITION

156.] Foot strain is a painful condition of the foot induced by the subjection of its ligamentous structures to a prolonged stretching force.

2. AETIOLOGY

Function of ligaments

Ligaments are designed to prevent excessive movements at joints; owing to their lack of elasticity, they are not adapted to withstand a prolonged stretching force, although they can resist sudden stretching forces, and frequently have to do so. When subjected to prolonged stretching, ligaments become painful because of the development of a state of inflammatory reaction. By the term inflammatory reaction is meant the condition which results from dilatation of the vessels and capillaries with exudation from them, and to a small extent infiltration with leucocytes. Under normal conditions the corresponding muscles protect the ligaments from strain for, owing to their structure and their state of active tone, they are capable of taking most of the load themselves. If the tone of the muscles of the leg and foot fails through fatigue, the whole strain of weight bearing falls on the ligamentous structure of the foot and the condition of foot strain develops.

Function of muscles

Some types of feet are, however, more liable to foot strain than others and the accurate assessment of any particular foot calls for a knowledge of certain aspects of the anatomy of the foot and their functional implications.

3. SURGICAL ANATOMY

Functions of foot

The foot has two main functions to subserve:

(1) It must act as a pedestal in standing.

(2) It must act as a lever to propel the body forwards in walking and running.

As a pedestal

(1) When the foot is functioning as a pedestal, it should present as large an area to the ground as possible, so that the body-weight may be distributed to the greatest possible advantage. Moreover, if the whole of the sole of the foot

When the patient's occupation entails long hours on the feet, supports may have to be provided as a permanent measure, so as to reinforce the action of the muscles in supporting the foot and relieve them from excessive work.

Choosing supports Such supports are best made out of cork, which is light, cool and resilient (Figs. 61 and 62). They must be made to measure individually for each foot. Steel supports are only necessary when it is not possible to provide shoes with strong enough shanks to hold up the foot properly.

Finally, it may be necessary sometimes to advise the patient to change his occupation, if his feet are such that they cannot be made to stand up to the strain in spite of the measures outlined above.

5. OPERATIVE TECHNIQUE

Elongation of tendo Achillis (tendo calcaneus)

This operation is performed through a slightly curved incision just lateral to the tendon. *Division of tendon* In children, the sheath of the tendon is divided to expose the tendon; in adults, the sheath is scarcely identifiable. The tendon is divided by a long oblique incision in the coronal plane. The incision commences on the deep surface of the tendon just above the calcaneum and emerges upon its superficial surface as far proximally as possible.

Method of suture The foot is now dorsiflexed to a right angle and the tendon carefully sutured all round the periphery of the area of the two overlapping ends of the tendon. Fine stainless-steel wire and nylon monofilament are the most satisfactory suture materials.

After-treatment It is not necessary to put the foot and leg in plaster, since plaster cannot prevent tone, or active contractions of the muscle, and therefore does not *obviate strain upon the line of suture. Six weeks should be allowed before any* weight is borne on the foot.

Subcutaneous tenotomy of the tendon is not advised, even in children.

PART II
ANTERIOR FOOT STRAIN

1. DEFINITION

Anterior foot strain is a term used to describe a painful condition of the fore part of the foot resulting from a mechanical breakdown.

2. AETIOLOGY AND SURGICAL ANATOMY

Whereas the foot as a whole functions as a lever to propel the body forwards, *Fore-foot as fulcrum* the main function of the fore-foot is to provide a stable fulcrum upon which the foot can pivot. The fulcrum for this movement is provided by the 5 metatarsal heads, which, being bound together by strong ligaments, together form a transverse rounded bar upon which the foot rolls forwards and upwards.

Arches of fore-foot In the normal foot this fulcrum is arched upwards to form the transverse arch of the foot, and also forwards owing to the fact that the second, third and fourth metatarsals are longer than the first and fifth, though there is a

Muscle weakness

(3) Poor muscle tone, and muscle weakness following any illness or period of recumbency, will predispose to fatigue and subsequent foot strain.

4. TREATMENT

Since foot strain is always primarily due to muscle fatigue, the first stage of treatment in acute cases consists in rest. In such cases, 24–48 hours of complete rest to the foot will save much time and trouble. With rest the symptoms very rapidly subside and the muscles recover from their state of fatigue. Only then should active treatment be commenced. This should consist of a course of graduated exercises designed to improve muscle tone and to correct faulty habits of standing and walking. Such treatment will suffice to cure cases of recent origin in which the cause, such as a recent illness or a period of over-strenuous activity, is no longer operating. In chronic cases, however, the

Acute cases

Chronic cases

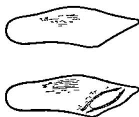


Fig. 61.—(Foot strain.) Cork valgus or long arch support.

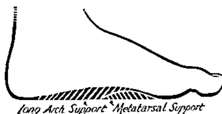


Fig. 62.—(Anterior foot strain.) Valgus support combined with metatarsal pad made of compressed felt.

cause of the condition must be dealt with if subsequent relapse is to be avoided.

First, any local predisposing cause should be assessed and dealt with if necessary. In the case of "short tendo Achillis" it is often sufficient to compensate for it by raising the heels of the shoes. In severe cases, however, it may be necessary to lengthen the calf muscles by elongation of the tendo Achillis. If the foot is stiff or has lost any of its normal mobility as a result of the formation of fibrous adhesions, a manipulation of the foot under anaesthesia may be of considerable benefit.

Footwear

The patient's footwear should then be examined and altered or replaced if necessary. Shoes should have strong shanks and should be well-fitting round the heel and the region of the long arch. The height of the heel should correspond to the length of the calf muscles and should on no account be too low.

Foot supports

In some cases the provision of long arch supports may be indicated. The function of a long arch support is to undertake some of the work normally done by the muscles, namely, to relieve the ligamentous structures from strain. If the muscles have been temporarily weakened by illness or recumbency, such a support relieves the muscles from overwork until they have recovered sufficiently to be able to undertake their normal duties without ill effect. Used in this way, in conjunction with a course of graduated physiotherapy, they are of benefit and do not weaken the muscles of the foot, as is commonly stated. On the contrary, by obviating fatigue in weakened muscles, they make rehabilitation of such muscles possible.

amount of flexion at the proximal interphalangeal joint and the amount of extension at the metatarso-phalangeal joint. As a result, the toes are placed in the optimal position to allow the continued action of the long flexors to exert considerable pressure on the ground through the digital pads.

If the toes are cramped in tight socks or shoes, or if painful corns or other local painful lesions are present, the combined harmonious function of these two groups of muscles is impeded or inhibited. The toes then fail to take their share of the body-weight and pain and callosities develop in the region of the metatarsal heads.

3. TREATMENT

The main problem in treatment is to relieve pressure and strain from the region of the anterior arch and the metatarsal heads. This will be considered under three headings:

(1) Removal of the cause.
(2) "Re-education" of the toe function.
(3) Palliative measures.

(1) Removal of the cause

In cases in which some deformity, such as hallux valgus, is the primary cause, its correction by operation must be considered. This may not always be justifiable, however, since correction of the deformity may itself result in some weakening of the fore-foot. A decision should be reached only after consideration of all the factors involved, these being, age and occupation of the patient, the degree of deformity and the nature and severity of the symptoms. *Correction of deformities*



Fig. 63.—(Anterior foot strain.) Exercise for toe function. Downward pressure of toes on edge of book forces up metatarsal heads.

Any other minor painful lesions, such as corns or ingrowing toe-nails, must be dealt with, otherwise it will be impossible to restore function to the toes. *Removal of sources of pain*

Finally, the patient's shoes must be inspected. If the toes are being cramped in tight shoes, or forced into the toe-caps by excessively high heels, all treatment is doomed to failure.

(2) "Re-education" of the toe function

When the cause has been dealt with as far as possible, treatment should be directed towards restoring proper active function to the muscles controlling the toes.

The only effective exercises are those which induce the long flexors and the intrinsic muscles to work together. Such exercises as picking up marbles with the toes are useless, for they exercise the long flexors only, that is, the prehensile action. The most effective exercise is as follows. The patient stands or sits with the toes resting upon the edge of a book or piece of wood half an inch thick, the rest of the foot being on the ground as shown in Fig. 63. He is then taught to force the metatarsal heads off the ground by pressing upon the book with the toes. At first, only the long flexors will contract, and the toes *Re-education exercises for toe function*

considerable variation in the relative lengths of the metatarsals in different individuals.

Effect of flattening of arch

Owing to these two curves, weight is borne mainly by the first and fifth metatarsal heads when standing at rest, but as the heel is raised the other metatarsal heads take more and more of their share of the body-weight. Flattening of the transverse arch results in extra weight being borne by them even when standing. When the heel is now raised the weight will be borne by them exclusively, owing to their length. This excessive pressure leads to the *formation of painful callosities* under them.

In civilized communities the splayed fore-foot with a flattened transverse arch and with painful callosities under the second, third and sometimes fourth metatarsal heads is the commonest of all the causes of painful feet and is therefore a problem of considerable importance. Its causes are mechanical and functional.

(1) Mechanical causes

Metatarsus varus

Congenital varus deformity of the first metatarsal with secondary hallux valgus is the commonest cause of anterior foot strain. It results in marked splaying of the whole fore-foot as well as in flattening of the transverse arch.

Metatarsus elevatus

Congenital metatarsus primus elevatus is also a common cause. It will be appreciated that this condition will produce almost a reversal of the transverse arch of the foot.

High heels

Anterior foot strain is much more common in women than in men and this is largely due to the former wearing high heels, which tip the foot forwards on to the metatarsal heads even in the standing position.

(2) Functional causes

Functions of toes

As the heel is raised from the ground, the whole of the body-weight falls upon the area of the fulcrum formed by the metatarsal heads, and this alone is too small an area to withstand the load. Normally, however, the pads of the toes are pressed firmly on the ground whenever the heel is raised, thereby relieving the metatarsal heads of some of the weight and enlarging the effective area of the fulcrum. This has the added advantage that it stabilizes the fulcrum on the ground and counteracts its tendency to skid backwards (as happens when walking upon slippery surfaces).

Proper active functioning of the toes is essential if the fore-foot is to play its part adequately, and it is therefore important that the muscle actions involved should be understood.

Muscles acting upon the toes

There are three groups of muscles which act upon the toes:

(a) The long extensors, which extend the metatarso-phalangeal joints.
(b) The long flexors, whose primary action is to flex the interphalangeal joints.
(c) The intrinsic muscles, comprising the lumbricals, interossei and short flexors, whose action is to extend the interphalangeal joints while allowing and assisting flexion at the metatarso-phalangeal joints.

Action of the muscles

When the foot is on the ground and bearing weight, contraction of the long flexors tends to draw the terminal phalanges proximally, that is towards the heel, and would result in buckling up of the toes but for the simultaneous action of the intrinsic muscles, which control the movement and limit the

region causes an increase in the height of the long arch and, incidentally, a flattening of the transverse arch.

Paralysis of the intrinsic muscles occurs in a variety of conditions, the commonest being nerve injuries, certain nervous diseases—such as Friedreich's ataxia—and peripheral neuritis. The condition is not a common sequel to infantile paralysis since, in this condition, the long flexors and extensors are usually affected as well. *Causes of paralysis*

Pes cavus may also occur independently of clawing of the toes, either as a congenital condition or as a result of contracture of the plantar fascia.

3. CLINICAL PICTURE

The symptoms in general are those of a severe and persistent anterior foot strain. As a result of the cavus deformity, the metatarsal heads are unduly prominent in the sole of the foot and the weight-bearing area is markedly diminished. The failure of the toes to take their share of the weight throws still further strain on to the metatarsal heads and painful callosities develop under them. *Anterior foot strain* *Callosities under metatarsal heads*

Corns, too, may form upon the dorsal prominences of the toes as a result of pressure and friction in the shoes. In fact, the high long arch and deformed toes make it almost impossible to fit the feet into ordinary footwear. *Corns*

4. TREATMENT

(1) *Conservative measures*

In some cases, such as those due to peripheral neuritis or nerve injuries, the paralysis of the intrinsic muscles may be only temporary. Although recovery may take place, return of function may not occur spontaneously if the toes have become deformed in the meantime, for this will have upset the line of pull of the intrinsic muscles. If the deformity has not yet become fixed, much can be done by re-educating the function of the intrinsic muscles, first by electrical stimulation, and then by exercises of the type described for anterior foot strain (p. 139). A preliminary subcutaneous tenotomy of the extensor tendons is sometimes necessary if they are very taut. *Re-education* *Tenotomy*

(2) Operative measures

In long-standing cases and in cases in which the paralysis is permanent, re-educational measures are useless. If the symptoms are severe and palliative measures, such as those described for anterior foot strain, are ineffective, operative correction must be considered. Operative measures fall into two categories:

(a) Those designed to correct the deformity of the foot or the toes. *Types of operation*

(b) Those designed to restore function as well as to correct the deformity.

5. OPERATIVE TECHNIQUE

(1) Correction of deformity

(a) *Steindler's operation*

This operation is designed to correct the cavus deformity of the foot. It is primarily indicated in those cases in which the cavus deformity is not associated with clawing of the toes, (for example, congenital cases). It should not be *Indications for operation*

will curl under or buckle, so that they may have to be held flat on the book by the hand of the masseuse. Once the trick has been learnt of bringing the intrinsic muscles also into play, so that effective pressure of the pads of the toes upon the book forces the metatarsal heads off the ground, the patient can continue the exercise at home—a few minutes night and morning being sufficient. In difficult cases, faradic stimulation of the intrinsic muscles may be necessary in the initial stages.

(3) Palliative measures

Use of metatarsal supports

If good function cannot be restored to the toes, palliative measures should be adopted to relieve the excessive weight borne by the metatarsal heads. If this weight cannot be distributed forwards on to the toes, it must be spread backwards by the provision of supports placed behind the metatarsal heads. Fig. 61 shows how the weight-bearing area is enlarged by this means. Often the anterior or metatarsal support may be combined with advantage with a long arch support (Fig. 62).

PART III
PES CAVUS AND CLAW TOES

1. DEFINITION

Pes cavus is a condition in which the long arch of the foot becomes exaggerated. Although it may occur as a separate entity, it is usually associated with clawing of the toes. In the latter deformity, the toes are fixed in a position of flexion at the interphalangeal joints and extension or hyperextension at the metatarso-phalangeal joints.

2. AETIOLOGY

Paralysis of intrinsic muscles

Clawing of the toes is due to paralysis, or to a failure of the function of the intrinsic muscles of the foot, that is the lumbricals, interossei and short flexors.

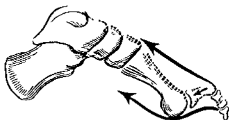


Fig. 64.—(Pes cavus and claw toes.) Unopposed tone of long flexors and extensors transmitted to foot as a downward thrust along proximal phalanx.

Effect upon toes

The action of these muscles has been discussed in the preceding section. When they are paralysed, the toes are drawn into the deformed position by the tone of the long flexors and extensors. This "claw-toe" deformity is exactly comparable to the clawing of the fingers which occurs with ulnar paralysis.

Effect upon foot

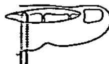
The cavus deformity of the foot develops as a secondary phenomenon. The backward pull of the tendons of the long flexors and extensors, unopposed by the interossei, lumbricals and short flexors, has a similar buckling effect upon the foot to that which it has upon the toes. Fig. 64 shows how the pull of these muscles is transmitted to the foot along the dorsiflexed first phalanges, causing a downward thrust on the metatarsal heads. The resulting depression of the anterior metatarsal

may be capable of doing this while the foot is off the ground, they cannot do so when acting against the weight of the body, since they have no effective point of counter-pressure upon the ground. To expect them to have any beneficial effect when standing or walking is equivalent to expecting an attempt to lift oneself up by pulling on one's own shoe laces to prove successful. Any benefit derived from the operation is due to the fact that the extensor tendons have been tenotomized.

(*b*) *Interphalangeal arthrodesis of the toes* (*Lambrinudi*)

Object of operation This operation is based upon the argument that, if the interphalangeal joints of the toes are fixed, the long flexors must exert their action upon the metatarso-phalangeal joints. They will then produce the same functional effect as is normally achieved by the combined action of the long flexors and intrinsic muscles. Thus the operation provides an opportunity for the correction of the deformity of the toes as well as for the restoration of their essential functions. *Results* In practice the results of this operation have proved most satisfactory and, in addition, it usually brings about considerable improvement in the cavus deformity of the foot.

Incision The operation is performed through a longitudinal dorsal incision on each toe. The extensor expansion is excised, and the lateral ligaments of the interphalangeal joints divided to expose the joint surfaces. These are cut off squarely with fine bone-cutting forceps, just sufficient cortical bone being removed to leave flat surfaces of cancellous bone in apposition. This is not easy and requires care and patience. One end of a loop of strong nylon thread is now passed down either side of the proximal phalanx to emerge upon the plantar aspect of the toe as shown in Fig. 66.


FIG. 66.—(Pes cavus and claw toes.) Method of placing nylon thread round proximal phalanx.

Use of sole plate After the skin incisions have been sutured, the foot is placed upon the sole plate shown in Fig. 67. The sliding platform is adjusted so that it supports the pads of the toes. The loops of nylon are now tied under the respective prongs of the sole plate sufficiently tightly to hold the toes in the corrected position.


FIG. 67.—(Pes cavus and claw toes.) Sole plate for arthrodesis of toes.

After-treatment The splint is retained for 6 weeks. At the end of this period, if the joints are firmly ankylosed, the splint is removed after the nylon threads have been cut and withdrawn. Re-educational exercises are now commenced and weight-bearing can usually be permitted after about 2 weeks.

PART IV
CLUB-FOOT

1. DEFINITION

Club-foot is the generic name given to a variety of congenital deformities of the foot. The individual varieties are distinguished by descriptive names

employed after the age of 10–12 years, for by then the bones have become permanently altered in shape and correction of the deformity by this operation will upset the alignment of the joints and leads to traumatic arthritis later.

Incision

The operation is performed through a lateral incision as shown in Fig. 65 (B). The superficial surface of the plantar fascia is exposed by dissecting off the subcutaneous tissues. It is then completely divided at its attachment to the calcaneum and freed from the bone, together with the origin of the short muscles of the foot, this separation being carried forward far enough to expose the bony vault of the foot and the long and short plantar ligaments. On the medial side of the calcaneum this separation can usually be done blindly with a curved periosteal elevator. If necessary, however, a separate incision along the medial border of the foot may be used for this purpose. The mass of muscle and fascia is now free to slide forwards between the bones and the superficial tissues.

Separation of tissues from calcaneum

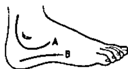


Fig. 65.—(Pes cavus and claw toes.) A: Incision for triple arthrodesis. B: Incision for Steindler operation. (This is the lateral aspect of the foot.)

Division of ligaments

The long and short plantar ligaments are next divided and the foot wrenched out flat. Occasionally it may be necessary to divide the plantar calcaneo-navicular (spring) ligament through the medial incision.

After-treatment

No deep sutures are required. After suture of the skin, the foot is immobilized in a padded plaster cast before the tourniquet is removed. After 10 days, the plaster is removed, further manual correction being carried out if necessary; the stitches are then removed and a non-padded cast applied. This is retained for 1 month.

(*b*) *Plantar fasciotomy*

Although subcutaneous division of the plantar fascia is a simple measure, it is rarely called for in practice. It is only effective in slight and non-progressive cases and, in these, conservative measures will usually suffice.

(*c*) *Triple arthrodesis*

Modifications to correct cavus

If the age of the patient contra-indicates the Steindler operation, or if there is some other associated deformity which also requires correction, some modification of triple arthrodesis should be employed (*see* p. 158). By removing extra bone from the head of the talus and from the calcaneo-cuboid joint, the skeletal elements of the foot can be shortened sufficiently to permit the cavus deformity to be corrected without upsetting the alignment of the remaining joints.

(2) Restoration of function

(*a*) *Tendon transplantation*

In this operation the extensor tendons are divided on the dorsum of the toes and transplanted into the respective metatarsal heads by threading them through holes drilled in the bones.

Fallacies

This operation was devised under the misconception that the extensors would then exert a lifting action upon the metatarsal heads. Although they

Finally, there is often some medial rotation in the tibia itself, as a result of which the ankle and foot are directed to some extent medially when the knee is facing directly forwards. *Rotation of tibia*

Talipes calcaneo-valgus is the next most common variety and is the reverse of the preceding one. The foot is dorsiflexed at the ankle joint and is in a position of extreme valgus at the subtalar joint. There is usually no deformity at the mid-tarsal joints, though some adduction of the fore-foot may be present occasionally. *Talipes calcaneo-valgus*

Various other varieties occur occasionally, the most common being an adducted fore-foot without any other associated deformity. *Other varieties*

4. TREATMENT

Talipes equino-varus is not only the most common and severe form of club-foot, it is also the most resistant to treatment, and the one in which relapses are most frequent. The treatment of this condition will be described in detail. The treatment of other varieties of club-foot should be conducted upon similar lines with the necessary modifications appropriate to each.

(1) Method I—rapid correction of the deformity

The first step in treatment consists in the reduction of the various elements of the deformity in proper sequence by manipulation and the use of some retentive appliance to hold the foot in the corrected position.

The manipulations should be performed with the hands alone and under general anaesthesia. The adduction of the fore-foot should be corrected first, for the fixed deformity of the back part of the foot helps to hold it steady while the fore-foot is being forcibly abducted upon it. When this element of the deformity has been fully corrected, the whole foot is forced round into a valgus position. Finally, the foot is forced upwards to overcome the plantar flexion at the ankle joint. Each element of the deformity must be *over-corrected*, and this will require from 1 to 3 manipulations, according to the severity of the condition and the age of the patient, the manipulations being performed at intervals of from 2 to 3 weeks. *Method of correction* *Importance of over-correction*

During these periods, some method of maintaining the corrected position must be employed. The methods of choice are: *Maintenance of correction*



FIG. 68.—(Club-foot.) Method of holding foot with strapping for application of plaster.

(*a*) *Plaster of Paris*

This is the most efficient and effective means of holding the foot, but it requires skill and practice to apply a plaster properly to a baby's foot. Before applying the plaster, one end of a strip of strapping is applied to the medial border of the foot. An assistant holds the other end in one hand and grips the leg just below the knee with the other. By pulling laterally on the strapping and at the same time twisting the leg medially with the other hand, the corrected position can be maintained while the plaster is being applied (Fig. 68). A very small amount of padding is used along the medial border of the foot and over the lateral malleolus. While the plaster is *Method of application*

with the word "talipes" prefixed to indicate that the deformity described refers to the foot.

2. AETIOLOGY

Many theories have been advanced to explain the development of these deformities. It seems probable that two main factors are responsible:

Primary congenital defect

(1) A primary defect in development of the mesodermal structures. In severe cases, the muscles, bones and joints are affected by an arrest of their final differentiation; this condition, which gives rise to multiple deformities throughout the limbs, is recognized by the term arthrogryphosis multiplex congenita. In mild cases of this condition, there may be little abnormality to detect apart from the club-foot deformities.

Secondary causes

(2) The actual form which the deformity takes is influenced by the position of the foot *in utero*, and by such outside factors as hydramnios and other abnormalities of the amniotic sac.

3. SURGICAL ANATOMY

Joint systems of the foot

From the practical point of view the foot may be regarded as having three main joint systems:

(1) The ankle joint, which permits plantar flexion and dorsiflexion of the foot.

(2) The subtalar joint, which functions in conjunction with the talo-calcaneo-navicular and calcaneo-cuboid joints. The movements of the foot which take place at this joint system consist of inversion (that is, medial rotation of the foot about an antero-posterior axis), combined with adduction (that is, medial rotation about a vertical axis), and the reverse combinations of eversion and abduction. The position adopted by the foot as a result of these movements is known as a "varus" or "valgus" attitude as the case may be.

(3) The mid-tarsal joints, that is to say, all the joints in which the navicular, cuboid and cuneiform bones take part. The movements which take place at this complex joint system consist in adduction and abduction together with inversion and eversion of the fore-foot upon the hind-foot.

In congenital deformities, the foot adopts an extreme position at any one, or at a combination of these joint systems.

Talipes equino-varus

Talipes equino-varus is the commonest variety of club-foot. The foot is held in an extreme position at all three joint systems. At the ankle it is plantar flexed, at the subtalar joint adducted and inverted, and at the mid-tarsal joints the fore-foot is adducted on the hind-foot. At the subtalar joint the position may be so exaggerated that the head of the talus is dislocated on to the dorsum of the foot. As the socket it normally occupies is empty, the navicular is retracted backwards, so that it abuts against the medial malleolus. The resultant shortening of the medial border of the foot is partly responsible for the adduction of the fore-foot.

Appearance of foot

The sole of the foot thus faces medially, or even medially and upwards, and it is kidney-shaped, owing to the adduction of the fore-foot. The heel is obscured, owing to plantar flexion at the ankle-joint, and it shows as a mere button upon the back of the foot.

the child's mother or nurse how to do the manipulations. For this reason, the method has a very limited application, but excellent results can be obtained under suitable conditions if treatment is commenced from birth and adequate supervision can be given.

5. INDICATIONS FOR SURGICAL INTERVENTION

After the age of 2½–3 years, it is no longer possible to correct the deformity by manipulative methods. In these late cases, or in cases in which a relapse has occurred, operative measures may have to be employed. The results of operative treatment always fall far short of perfection, however, and operation should be undertaken only as a last resort.

Lengthening of tendo Achillis

Elongation of the tendo Achillis is very occasionally indicated in late unreduced cases. Subcutaneous tenotomy is not advised. It is much safer to perform open elongation of the tendon as described on p. 137.

Open reduction

Open reduction (Brockman, 1930) is sometimes necessary in unreduced cases after the age of 3 years. The operation has a very limited field of usefulness, as it is so difficult to achieve adequate correction without over-correction.

Bone operation

After the age of from 5 to 6 years, the bones are so far developed that operative treatment which is restricted to the division of soft parts is useless. After this age, the foot can only be made plantargrade by some form of bone operation. A suitable modification of the triple arthrodesis gives the most certain and permanent result. If the equinus element of the deformity is marked, the Lambrinudi "drop-foot" modification should be employed (p. 159). In order to correct the inversion, more bone should be removed from the lateral than from the medial parts of the articular surfaces of the subtalar joint. Finally, by removing sufficient bone from the calcaneo-cuboid joint, any residual adduction deformity of the fore-foot can also be corrected. Operations of this type should be delayed until the age of 10 years. At earlier ages the bones are too cartilaginous to permit satisfactory bony ankylosis.

Modifications of triple arthrodesis

Correction of tibia

It will sometimes be found that, although satisfactory correction of a club-foot has been achieved, the child still walks with the feet rotated medially. This is due to the persistence of a medial rotation twist in the shaft of the tibia, an element of the deformity which is frequently overlooked. It is sometimes necessary, therefore, to complete the cure by performing a rotation osteotomy of the tibia.

6. OPERATIVE TECHNIQUE

(1) Elongation of tendo Achillis

(2) Triple arthrodesis

(3) Open reduction (Brockman)

Incision

The incision depicted in Fig. 71 is slightly modified from that described by Brockman (1930). The curve that follows the bony outline of the foot facilitates the exposure and, if any contraction of the scar should occur subsequently, its effect would be less serious than with a straighter incision.

Exposure

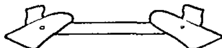
The plantar fascia and the short muscles of the foot are separated from their origin on the calcaneum as in the Steindler operation (p. 142). The separation of the soft tissues from the under-surface of the bony vault of the foot is

setting, the fully corrected position is maintained by pressing the sole of the plaster upwards and laterally with the palm of the hand.

Disadvantages of plaster

A plaster splint has the disadvantage that it immobilizes the muscles and will lead to permanent wasting if it is retained over a long period. It should therefore only be employed in the early stages. As soon as the deformities have been fully corrected, it should be discarded in favour of the Denis Browne splint described below.

Denis Browne splint



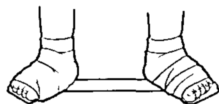


FIG. 69.—(Club-foot.) Denis Browne splints.

(*b*) *The Denis Browne splint*

This consists of two metal sole plates with lateral flanges, to which the feet are fixed with strips of strapping, as shown in Fig. 69. The two sole plates are then bolted to a transverse bar. *Before the nuts are finally tightened*, the plates are rotated out to the desired angle. In unilateral cases, the normal foot is fixed in a neutral position. The transverse bar can also be bent to evert the feet.

Advantages

The great advantages of this splint are that each foot controls the position of the other, while, at the same time, the child can kick and exercise its muscles freely and even stand up in the splints.

Disadvantages

It is difficult, however, to keep the heel in contact with the sole plate unless complete correction of the deformity has already been achieved. If the heel rides up off the splint, the foot may become dorsi-flexed at the mid-tarsal instead of at the ankle joint, producing a "rocker" foot with an outer border which is convex downwards. It is in order to avoid the possibility of producing this false correction that some surgeons prefer to use plaster in the early stages.

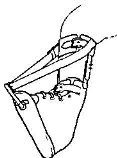


FIG. 70.—(Club-foot.) As in Fig. 69—but showing the foot in a Denis Browne boot.

Second stage of treatment

When the deformity has been completely corrected, the second stage of treatment begins. The feet must be kept in the Denis Browne splints until the muscles, especially the peronei, have had time to re-adapt themselves and have developed sufficient power to enable the foot to be brought into the fully corrected position actively and without assistance.

This may take many months, especially if the initial treatment was not started soon after birth. In the later stages, and in children over 1 year old, the sole plates can be changed with advantage for Denis Browne boots (Fig. 70).

Third stage—after-care

The third stage consists in after-care, which often lasts throughout childhood. The child should be fitted with strong boots or shoes with straight inner borders and outside wedges if necessary. The feet should be inspected at regular intervals to guard against relapse.

(2) Method II—gradual reduction

Gradual reduction

In this method, the deformities are corrected by repeated manipulations of the foot, carried out several times a day. *It is therefore necessary to teach*

PART V
HALLUX VALGUS

1. DEFINITION

Hallux valgus is a complex deformity in which the obvious abnormality is a deviation of the great toe towards the lateral side of the foot.

2. AETIOLOGY

Primary deformity

The primary deformity consists in a congenital malposition of the first metatarsal, which is inclined medially away from the other metatarsals and, in addition, is shorter. The condition is similar to that found in the anthropoid foot, in which the hallux functions as a thumb, and it may be regarded as an example of atavism.

Secondary deformity

As a result of this primary deformity, the phalanges of the first digit, when they are in line with the rest of the toes, make, with the first metatarsal, an angle with its apex directed medially. The flexor and extensor tendons become displaced to the lateral side of the metatarso-phalangeal joint, and their tone and active contractions tend to increase the angulation of the great toe and tend also to draw it further laterally, while the head of the first metatarsal is displaced still farther to the medial side. These deformities have a tendency to be slowly progressive and this tendency will be increased by the pressure of socks and shoes on the medial side of the great toe. Owing to the narrow and centrally pointed shoe commonly worn by women, the deformity increases more markedly in them than in men.

As a result of the above changes, the fore-foot becomes splayed and the transverse arch of the foot becomes weakened and flattened. Further, owing to this splaying and to the instability of the first metatarsal head, too much pressure is borne by the second, third and fourth metatarsal heads and painful callosities form beneath them.

3. CLINICAL PICTURE

Bunion

When the secondary deformities are fully developed, the great toe may come to lie almost transversely either on top of or beneath the neighbouring toes. The head of the first metatarsal projects on the medial side of the foot and a bursa develops over it, producing the condition known as a bunion. The whole fore-foot is splayed and flattened and there are callosities under the second and third metatarsal heads. Finally, the metatarso-phalangeal joint of the great toe undergoes arthritic changes and becomes painful to walk upon. When the patient seeks advice, it is nearly always on account of pain and rarely for cosmetic reasons alone.

Arthritic changes

4. INDICATIONS FOR SURGICAL INTERVENTION

In children

The primary varus deformity of the first metatarsal is never obvious in a child's foot. It is only during adolescence, when the secondary changes begin to develop, that the condition first becomes recognizable. In practice, patients

carried forwards to expose the under-surface of the plantar calcaneo-navicular (spring) ligament and the insertion of the tibialis posterior, care being taken to avoid damage to the posterior tibial vessels and nerve and the long flexor tendons.

It will now be seen that this ligament is very short, and that the socket for the head of the talus is obliterated by the approximation of the navicular to the medial malleolus with which it may be in actual contact.



Fig. 71.—Incision for open correction of club-foot.

Division and excision of contracted structures

The fibrous tissues which occupy any intervening space are excised, together with the plantar calcaneo-navicular ligament. The tightest bands of the fanlike insertion of the tibialis posterior tendon are also divided. Part of the insertion should be preserved, if possible, otherwise ultimate over-correction is sure to occur.

Reduction of deformity

The foot can now be swung outwards and upwards so that the head of the talus is forced down into its normal position between the navicular and the medial malleolus.

After-treatment

The after-treatment is similar to that described for the Steindler operation (p. 142).

(4) Rotation osteotomy of tibia

Incision

The osteotomy is performed through a small, vertical incision at the upper end of the tibia about 1 inch below the tibial tubercle. The periosteum is divided and separated from the bone over a short distance. After division of the bone with an osteotome, the lower end is rotated laterally to the desired degree.

Method of fixation

A short Steinmann pin is now driven into each fragment. The projecting portions of the pins are incorporated in the plaster case which is applied after closure of the incision, and they serve to maintain the correct degree of rotation at the site of the osteotomy. Occasionally it may be found necessary to divide the shaft of the fibula as well.

7. RESULTS OF TREATMENT

Although it is nearly always possible to achieve sufficient correction to enable the patient to wear normal shoes in comfort, a perfect result of the treatment of a severe club-foot is the exception rather than the rule.

There are three main causes of failure:

(1) Delay in commencing treatment.

(2) A primary defect in development of the mesodermal structures, (for example, arthrogryphosis multiplex congenita).

(3) Failure to obtain and to maintain complete correction of the deformity.

Importance of after-care

It is only the third cause which is the fault of the surgeon, and it must be emphasized that the maintenance of correction over a prolonged period, that is, until the child can actively hold the foot in the fully corrected position, is of the utmost importance. The co-operation of the child's parents is essential in the later stages, and they should always be shown how to manipulate the feet daily—even after full correction has been obtained—and asked to encourage the child to do active corrective movements of the feet.

along the proximal phalanx (Fig. 72 (A)). (For alternative incision see Fig. 76.) The joint capsule is incised longitudinally in the line of the incision, and is reflected to either side to expose the joint surfaces. A sufficient amount of bone must now be removed from the metatarsal head (Mayo, 1908), or from the base of the phalanx (Keller, 1904), to allow the deformity to be corrected and, at the same time, to permit a free range of movement (Fig. 74). Removal of the metatarsal head deprives the foot of one of its main points for weight bearing, whereas removal of the base of the proximal phalanx leaves a functionless though freely movable toe. In practice there is little to choose between the results of these two alternatives. The decision should be dependent upon the relative state of the articular surfaces as seen at operation. Occasionally, when the joint is grossly arthritic, it may be necessary to remove bone from both articular surfaces.

Removal of bone

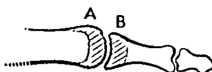


FIG. 74.—(Hallux valgus.) Showing amount of bone removed:
A: From metatarsal head (Mayo).
B: From base of phalanx (Keller).

It was formerly the practice to complete the operation by turning in a flap of fascia or the bursa itself to cover the raw bone surface. This procedure is unnecessary and, in fact, it does not favour the formation of a satisfactory new joint.

The success of this operation is far more dependent upon good after-treatment than upon operative dexterity. At the completion of the operation, the foot and toe are firmly bandaged in a corrected position before the tourniquet is removed and this dressing is not disturbed for 10 days. The stitches are then removed and graduated active assisted movements of the great toe commenced. No weight bearing is allowed for a minimal period of 3 weeks or until all inflammatory reaction has subsided and a good range of movement is possible in the new joint. The patient must subsequently wear well-fitting shoes provided with combined long and anterior arch supports, which should be retained for at least 6 months.

After-treatment

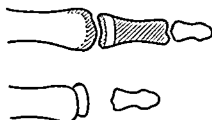


FIG. 75.—(Hallux valgus.) Showing bone removed in Girdlestone operation.

(3) Cap phalangectomy (Girdlestone)

This operation can be performed through the same incision as that described for the previous operation or through the alternative incision shown in Fig. 76.

Incision

The capsule of the joint is incised longitudinally and reflected to expose the joint surfaces. Both surfaces are then denuded of cartilage and cortical bone, as little bone as possible being removed. The distal two-thirds of the proximal phalanx is dissected out and removed (Fig. 75). The remaining proximal portion of the phalanx (to which the adductor of the great toe is attached) is now fixed by sutures to the metatarsal head in the position

rarely present themselves for advice until adult life is reached and the foot is causing pain. Although recently much attention has been directed to the problem of correcting the primary deformity at an early stage and before secondary changes have developed, the work is still in an experimental stage and no really satisfactory solution to the problem has yet been found.

In adults

In the adult it is not possible to restore the parts to their normal position, for adaptive changes have occurred in all the structures of the foot. In order to correct the deformity of the great toe, it is always necessary to remove bone, either from the head of the metatarsal or the base of the phalanx, and this in itself weakens the foot. Treatment, therefore, cannot be more than palliative and operative measures should never be undertaken for cosmetic reasons alone.

Causes of pain

The pain in cases of hallux valgus may be due to: (1) pressure over the bunion, (2) *arthritic changes in the great toe joint or* (3) *anterior foot* strain caused by the collapse of the transverse arch (*see* p. 138).



Fig. 72.—(Hallux valgus.) A: Incision for arthroplasty. B: Incision for bunionectomy.

If the pain is entirely localized to the bunion and the deformity of the great toe is not excessive, a simple bunionectomy is sometimes justifiable. It is not, however, a very satisfactory procedure, since the deformity of the great toe is liable to increase more rapidly thereafter. The more radical procedures are indicated in all cases in which the *deformity of the great toe is marked* and the joint itself is painful as a result of arthritic changes, but it must be remembered that any associated symptoms of anterior foot strain will not be alleviated by the operation, and may even be aggravated by it.

5. OPERATIVE TECHNIQUE

(1) Bunionectomy

The incision

A slightly curved incision is used, as shown in Fig. 72 (B), the skin and subcutaneous tissues being dissected downwards to expose the bursal sac. (For alternative incision see Fig. 76.) The soft tissues are divided down to the bone all round the sac. This procedure automatically opens the joint and exposes the articular surface of the head of the metatarsal. An osteotome is placed in the groove between the articular surface and the medial prominence of the metatarsal head (Fig. 73), and driven proximally so as to emerge upon the medial surface of the shaft of the metatarsal immediately proximal *to the bursal sac. The sac and the prominent part of* the metatarsal head can then be removed together. No deep sutures are required.



Fig. 73.—(Hallux valgus.) Showing bone removed for bunionectomy.

(2) Arthroplasty

Object

The object of this procedure is to form a new joint and, at the same time, to correct the deformity of the great toe.

Approach

The approach is usually made through a curved dorsi-medial incision similar to that employed for bunionectomy but, in this case, carried further distally

(3) Long-continued strain upon the joint resulting from faulty mechanics of the foot. It is not always appreciated how often faulty mechanics may be responsible for this condition and they must be considered in some detail.

Effect of elevation of first metatarsal head

The first metatarsal head should form one of the main weight-bearing points of the foot. If it were in an elevated position relative to the rest of the foot, it would be unable to take its fair share of the body-weight. Since it is essential for some weight-bearing point to be provided on the medial side of the foot, a compensatory mechanism develops to this end. The great toe is actively flexed by contraction of the long flexors, and the weight is then taken by the pad of the toe instead of by the metatarsal head. When the heel is elevated in walking, a passive dorsiflexion is imposed upon the metatarso-phalangeal joint. At the same time, the flexors are trying to keep the joint flexed and so an excessive strain is imposed upon it, and this is sufficient to cause degenerative changes resulting eventually in a severe osteoarthritis.

Causes of elevation of first metatarsal head

The common causes of this relative elevation of the metatarsal head are as follows:

(1) Congenital metatarsus primus elevatus

This also is an atavistic phenomenon (compare aetiology of hallux valgus). Although in this case the first metatarsal bone is not adducted, it is abnormally mobile, like the metacarpal bone of the thumb. This mobility often extends back to the intercuneiform joint and is demonstrated by the abnormally wide gap between the first and second cuneiform bones.

When weight is borne upon the foot, the first metatarsal head, instead of taking its fair share of the body-weight, becomes displaced dorsally in relation to the other metatarsal heads, owing to its mobility. The compensatory mechanism described above comes into play and active flexion of the toe then tends to displace the metatarsal head still further dorsally.

(2) Supinated fore-foot

This also is a congenital deformity, the whole fore-foot being supinated (inverted) in relation to the hind-foot. This has exactly the same effect in causing a relative elevation of the first metatarsal head and the same compensatory mechanism develops.

It should be noted that, in both the above conditions, a further compensatory mechanism develops. To assist in keeping the first metatarsal head on the ground, the whole foot is everted into the valgus position, so that it looks flat-footed and may develop valgus foot strain (compare valgus secondary to equinus, p. 135).

(3) Acquired causes

Following fractures about the ankle joint or of the calcaneum, or after an imperfectly performed subtalar arthrodesis, the foot may become fixed in a varus (or inverted) position. This in its turn elevates the medial border of the foot and with it the head of the first metatarsal bone.

3. CLINICAL PICTURE

The metatarso-phalangeal joint of the great toe has very limited mobility or no mobility at all and it may be fixed in a flexed position. There is a ridge of

indicated in Fig. 75. The advantages of the cap so formed are: (a) when it has united with the metatarsal head the bone is restored to its normal length; (b) the new joint which forms between the cap and the proximal end of the distal phalanx is in correct alignment with the other metatarso-phalangeal joints; (c) the action of the adductor muscle is now transferred to the first metatarsal and it will assist therefore in maintaining the bone in its correct alignment.

After-treatment

After-treatment is conducted on the same lines as that indicated for arthroplasty. No special precautions are required to retain the cap in place.

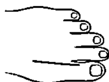


FIG. 76.—(Hallux valgus.) Dorsilateral alternative incision for operations on great toe joint.

(4) Alternative approach

Many surgeons favour a dorsilateral approach to the metatarso-phalangeal joint through a longitudinal incision, as shown in Fig. 76. After dividing the capsule of the joint on the dorsum and the lateral side, the toe can be dislocated medially, giving a wide exposure of the joint surfaces. Even a bunionectomy can be performed through this incision. It has the advantage of not leaving a scar over an area subjected to pressure. Further, the capsule of the joint is divided on the side where it is contracted instead of on its already stretched and weakened medial side.

6. RESULTS OF OPERATIVE TREATMENT

It must be emphasized that the operative measures described above do not restore the foot either anatomically or functionally to anything approaching the normal. A satisfactory result from the patient's point of view will be achieved only when these are employed solely for the relief of pain in carefully selected cases and when due care is given to the after-treatment. Under these circumstances, the results are on the whole good and do give the patient a foot that is comfortable and free from pain in the great majority of cases.

PART VI
HALLUX RIGIDUS

1. DEFINITION

Hallux rigidus is the term applied to an osteoarthritic condition affecting the metatarso-phalangeal joint of the great toe and resulting in marked loss of mobility of the joint.

2. AETIOLOGY

The osteoarthritic changes may be the result of:

(1) Injury to the joint, as, for example, when a heavy weight is dropped on the foot.

(2) Toxic or infective arthritis, and gout.

are very satisfactory. Although the mobility of the new joint may not be very great in every case, yet it is nearly always painless.

(2) Metatarsal osteotomy

In cases in which the primary cause is elevation of the first metatarsal head in relation to the rest of the fore-foot, the above operation should be combined with a correction of this deformity by osteotomy of the base of the first metatarsal, otherwise a relapse is certain. The operation presents certain technical difficulties for, whereas the new joint requires active treatment, the osteotomy site must be immobilized until union has taken place. To overcome these difficulties, one of the following alternatives is usually employed:

(a) A ball-and-socket osteotomy is performed at the base of the metatarsal with a curved gouge, as shown in Fig. 77 (a). This permits the shaft of the metatarsal to be angulated downwards without producing a gap in the upper *Curved type of osteotomy*

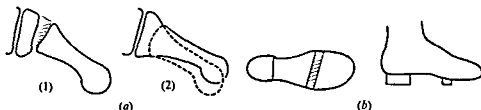


FIG. 77 (*a*).—(Hallux rigidus.) Alternative methods of performing metatarsal osteotomy for metatarsus primus elevatus. (1) Linear osteotomy with wedge-shaped graft. (2) Ball-and-socket type of osteotomy.
(*b*).—Metatarsal bar for hallux rigidus.

part of the osteotomy site. If this is done at the same time as the arthroplasty of the great toe joint, the foot must subsequently be immobilized in plaster to maintain the shaft of the metatarsal in the corrected position, but the plaster must stop short of the new metatarso-phalangeal joint, lest it should interfere with its movements. If the patient can spare the time, it is better for the operations to be done in two stages.

(b) A linear osteotomy is performed at the same time as the arthroplasty, and the shaft of the first metatarsal bone is angulated downwards, producing a V-shaped gap, which is filled with a bone graft cut from the shaft of the tibia (Fig. 77 (a)). This method has the advantage of maintaining the corrected alignment of the metatarsal without the need for immobilization in plaster. It does, however, require very careful operative technique and the free graft naturally takes longer to unite than the simple osteotomy. *Osteotomy with bone graft*

7. RESULTS OF TREATMENT

The results of operative treatment are in general more satisfactory in hallux rigidus than in hallux valgus, provided that the operation is undertaken for the relief of pain and not simply because the joint has lost its mobility. Failures and relapses occur most commonly in those cases in which a primary deformity of the first metatarsal bone is present but has been left uncorrected.

osteophytes all round the edges of the joint but most marked upon the dorsal surfaces. The skin under the joint is soft, showing that it is not taking pressure, while there may be callosities under the interphalangeal joint and the pad of the toe, and also under the second and third metatarsal heads. Although the patient may look flat-footed when standing (due to the compensatory valgus attitude explained above), yet the sole of the shoe is worn more upon the lateral than the medial side.

4. TREATMENT

This condition is not necessarily a painful one and it often progresses to a most advanced stage without causing the patient any real inconvenience. Pain, when present, is usually due to one of the following causes:

Causes of pain

(1) pain situated under the joint on weight bearing is due to pressure upon the irregular and osteophytic joint surfaces, especially of the sesamoid bones. This is best relieved by the provision of combined long and anterior arch supports to take the pressure off the joint (*see* p. 136);

(2) pain on the dorsal surface of the joint is due to impaction of the ridges of osteophytes and nipping of the synovial fringes. This can usually be relieved by a metatarsal bar fitted on to the shoe so that the foot can rock without causing dorsiflexion of the joints (Fig. 77 (b));

(3) pain in the region of the second and third metatarsal heads is due to secondary anterior foot strain (*see* p. 137);

(4) pain due to an inflammatory reaction in the joint, which is liable to occur in any osteoarthritic joint subjected to strain. Rest, heat and massage are frequently successful in relieving pains of this type.

5. INDICATIONS FOR SURGICAL INTERVENTION

Operative measures should be reserved for those cases in which persistent pain has resisted the conservative measures outlined above, but it should be remembered that pain often disappears spontaneously when the joint finally becomes completely ankylosed. At the same time, if there is marked osteophyte formation, it is extremely difficult to provide sufficient room in the shoe for the enlarged joint, and this alone may cause persistence of pain.

6. OPERATIVE TECHNIQUE

(1) Arthroplasty

The primary object of operative treatment is to provide a new movable joint for the great toe.

Keller operation

The Keller operation (p. 151) is generally regarded as being the simplest and most effective procedure, for removal of the base of the phalanx usually results in a more movable joint than is obtained after removal of the head of the metatarsal bone. It may, however, often be necessary to remove rather more bone than in cases of hallux valgus and also to trim the osteophytes off the metatarsal head.

With careful after-treatment the results of this operation in hallux rigidus

dissection is carried medially across the foot until the head of the talus is clearly defined (Fig. 78).

Peroneal tendons

The peroneal tendons are now exposed by opening the tendon sheath longitudinally throughout its length, except at one point at the anterior margin of the lateral malleolus, where it is possible to leave a loop of the sheath which will hold the tendons out of the way during the later stages of the operation.

Exposure of joint surfaces

The subtalar and talo-navicular joints are opened by dividing their capsules and ligaments, including the talo-calcaneal interosseous ligament. The subtalar joint is opened up by angulating the foot medially through two right

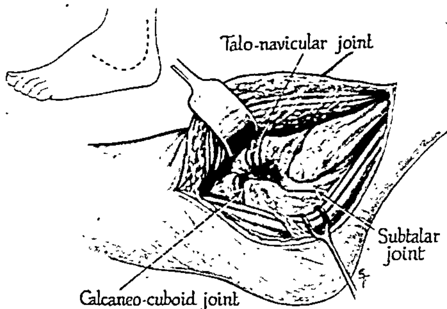


FIG. 78.—Drawing made during operation (triple arthrodesis) to show exposure.

angles, so that the sole of the foot faces upwards (Fig. 79). The foot is hinged to the talus by the medial part of the capsule of the subtalar joint, and further mobilization of the foot can be effected by stripping up the talar attachment of this capsule. This can be done simply by pushing the foot bodily upwards. It is an essential step in those cases in which it is desired subsequently to displace the foot backwards on the talus.

Removal of joint surfaces

The articular cartilage and cortical bone is now removed from the exposed joint surfaces of the talus, the calcaneum and the navicular. The calcaneo-cuboid joint is also opened up and its joint surfaces excised (Fig. 80 (a)).

Closure

The foot is replaced in its normal position, making sure that the bone surfaces fit accurately. No deep sutures are required. After closing the incision and before the tourniquet is removed, a plaster cast is applied over a firm wool and bandage dressing.

After-treatment

After 14 days, the plaster and dressings are removed and the position of the foot is adjusted if necessary. The stitches are then taken out and a non-padded plaster cast is applied. This cast is retained for a further 10 weeks.

PART VII
PARALYTIC DEFORMITIES OF THE FOOT

1. AETIOLOGY AND CLINICAL PICTURE

Causes of paralysis

Complete paralysis of the muscles controlling the foot causes gross instability. Partial paralysis causes not only instability but also deformity, which is due to the unopposed tone of the unparalysed muscles. The condition is usually the result of a lesion in the lower motor neurone, the commonest causes being anterior poliomyelitis and peripheral nerve injuries. In upper motor neurone lesions and in cerebral palsies, deformities are very liable to occur, although the foot is rarely unstable. Owing to the state of hypertonus in the anti-gravity muscles, the foot is usually drawn into a position of equino-varus.

2. TREATMENT

The surgical treatment of these conditions has now become standardized to a very large extent and is based upon the following considerations.

Ankle

The ankle joint is a structurally stable mechanism. The bony mortise formed by the tibia and fibula, into which the talus fits, ensures its stability even in the case of complete paralysis of all the muscles. The subtalar joint, on the other hand, is dependent for its stability upon muscle action. If this is defective, the foot will collapse into a varus or valgus attitude depending upon the particular muscle group or groups paralysed. With the exception of the talo-calcaneo-navicular and calcaneo-cuboid joints, the mid-tarsal joints of the foot are comparatively stable, even in the absence of good muscle control. The two former joints form part of the subtalar joint complex and these three joints should always be considered together.

Mid-tarsal joints

It follows that, if these three joints were fixed by arthrodesis, the foot would be rendered stable, even in the case of complete paralysis.

By modifying this operation in various ways, it has been found possible to correct almost any deformity of the foot.

Triple arthrodesis

The operation, which is known as "triple arthrodesis", therefore, forms the basis of all surgical treatment for paralytic conditions affecting the foot.

3. OPERATIVE TECHNIQUE

(1) Triple arthrodesis

Incision

The operation is performed through a "J"-shaped incision, as shown in Fig. 65 (A). A dorsal flap is dissected up to include all the structures on the anterior surface of the ankle and foot, including the extensor tendons, anterior tibial vessels and nerve and the extensor brevis muscle. In the proximal part *of the incision, the superior extensor retinaculum must be detached from the* anterior border of the fibula, and the dissection is continued deep to it as far as the anterior surface of the tibia. Unless the retinaculum is divided, it will be found that the dissection has been carried superficial to the vessels and tendons. In the distal part of the incision on the dorsum of the foot, the extensor brevis muscle is detached from its origin and included in the flap. This

redisplacement. The exact angle of section of the talus must depend upon the desired amount of correction of the equinus deformity, and it should be worked out beforehand with the aid of a tracing of a lateral skiagram of the foot.

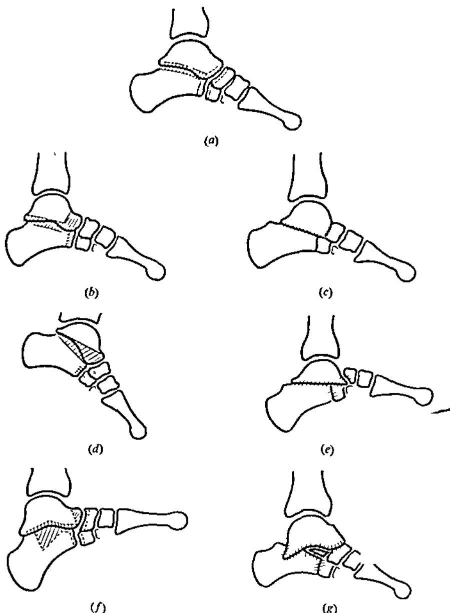


Fig. 80.—To show extent of bone section in triple arthrodesis and its modifications. (*a*) Triple arthrodesis; (*b*) and (*c*) Dunn's operation; (*d*) and (*e*) "drop-foot" operation (Lambrinudi); (*f*) and (*g*) reversed "drop-foot" operation (Lambrinudi).

(*e*) *The reversed "drop-foot" operation* (*Lambrinudi*)

This modification is used when the foot has become dorsiflexed as a result of paralysis of the calf muscles, the so-called "calcaneus deformity". After denuding the various joint surfaces as for a triple arthrodesis, the foot is

(2) Modifications

(*a*) *Dunn's operation*

If the foot is completely flail, it is advisable to displace it backwards on the leg. This helps to equalize the weight in front of and behind the ankle so that the foot hangs more horizontally and is prevented from being "dragged" along the ground. This can best be effected by excision of the head of the talus. The foot can then be displaced backwards until the navicular abuts against the neck of the talus as shown in Fig. 80 (b) and (c).

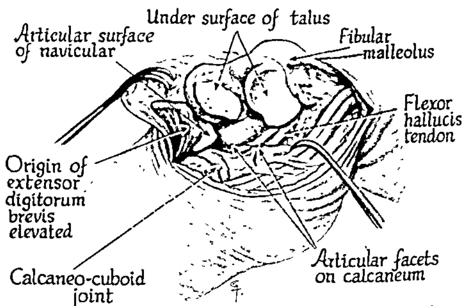


FIG. 79.—Drawing made after dislocation of foot at subtalar joint (triple arthrodesis).

(*b*) *For varus and valgus deformities*

In order to correct these deformities, more bone should be removed from the medial or lateral parts respectively of the articular surfaces of the subtalar joint. The effect is to produce a wedge-shaped gap facing medially or laterally and its closure will correct the deformity.

(*c*) *For dropping of the fore-foot*

This condition with a resulting pes cavus can be corrected by excision of sufficient bone at the calcaneo-cuboid and talo-navicular joints. Closure of the gap so formed shortens the bony structure of the foot and so permits the cavus deformity to be straightened out.

(*d*) *The "drop-foot" operation* (*Lambrinudi*)

In this modification of the triple arthrodesis, the talus is sectioned obliquely as shown in Fig. 80 (d) and (e), leaving only a beak of the head of the bone. This produces a V-shaped gap between the talus and calcaneum and its closure corrects the equinus deformity. Before the foot is replaced in position, a wedge is taken out of the lower part of the navicular to accommodate the remaining beak of the head of the talus. This permits the foot to be displaced backwards and also locks it in the corrected position, thus preventing

is now passed on either side of the head of the proximal phalanx to divide the collateral ligaments of the joint, keeping the blade parallel with the shaft of the phalanx so as to avoid damage to the digital nerve and artery.

A hole is now bored down the middle phalanx from its articular surface. This hole should be as large as the diameter of the phalanx will allow and about a quarter of an inch deep. The distal end of the proximal phalanx is now shaped to form a peg which will fit into this hole. Only the sides and under-surface of the phalanx are removed, so that the peg is mainly composed of the strong cortical bone on the dorsal surface (Fig. 81). It is important to keep the sides of the peg parallel, otherwise it will tend to slip out of the hole. *Forming peg and socket*

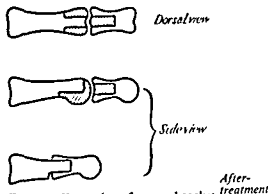


Fig. 81.—Formation of peg and socket for correction of hammer toe.

After suturing the skin, a collodion dressing is applied. This acts as an efficient splint and should be retained for 3 weeks. *After-treatment*

If any difficulty is experienced in overcoming the dorsiflexion at the metatarso-phalangeal joint, the extensor tendon should be tenotomized. *Tenotomy of extensor*

2. ELEVATED FIFTH TOE

(1) Definition and aetiology

Both congenital and acquired deformities of the fifth toe are relatively common. The deformity consists primarily of a position of extension at the metatarso-phalangeal joint. The toe may then become displaced medially by the pressure of socks and shoes so that it lies almost transversely on top of the fourth toe. In other cases the proximal interphalangeal joint becomes flexed to produce a claw-toe deformity. *Nature of deformity*

(2) Treatment

The fifth toe is of definite functional importance. Amputation of the toe interferes with the balance of the foot and also leads to dropping of the fifth metatarsal head, so that a callosity is likely to form under it. Finally, its removal destroys the even contour of the fore-foot, and is likely to lead to the formation of corns on the lateral side of the fifth metatarsal head and the tip of the fourth toe. Operative correction of the deformity should, therefore, always be undertaken in preference to amputation whenever possible. *Amputation contra-indicated*

(3) Operative technique

A V-shaped incision is made on the dorsum of the foot as shown in Fig. 82. The enclosed flap of skin is dissected up together with as much subcutaneous tissue as possible. The extensor tendon is divided and the capsule of the metatarso-phalangeal joint is incised across the dorsal surface of the joint and on both sides. The toe is now forced into hyperflexion, and then the base of the proximal phalanx is pushed proximally under the metatarsal head as far *Incision* *Correction of the deformity*

re-placed with the head of the talus lying on top of the navicular, the upper surface of this bone being bared to receive it. The prominent portion of the head of the talus is now cut off and placed upside down in the gap under the neck of the bone. It thus acts as a free graft filling the gap (Fig. 80 (f) and (g)).

4. RESULTS OF OPERATION

Functional results

The functional results of the triple arthrodesis and its modifications are so successful in correcting deformities of the foot and rendering it stable that they have entirely superseded other methods such as tendon transplantation. The ultimate disablement following these procedures is very slight, and the patient can take part in most active pursuits, including games, even when all the muscles are paralysed. A further great advantage is that special shoes or instruments can be dispensed with. This is important, both from the point of view of expense and in saving the patient from developing an inferiority complex.

Some difficulty is experienced in walking on uneven surfaces, since the foot has now lost much of its side-to-side movement, but this is the only real disability.

PART VIII
MINOR SURGERY OF THE FOOT

1. HAMMER TOE

(1) Definition and aetiology

Nature of deformity

In this deformity, the proximal interphalangeal joint of the toe becomes fixed in a position of flexion. The terminal joint is, however, usually hyperextended in contra-distinction to "claw toe" in which both joints are flexed. A corn is usually present over the dorsal prominence of the proximal interphalangeal joint.

Causes

The condition most commonly affects the second toe and is usually due to crowding of the toes in short, ill-fitting footwear or to an associated hallux valgus deformity. Occasionally it appears to be congenital in origin.

(2) Treatment

The condition can only be dealt with successfully by operative correction. Strapping and splinting the toe may result in some improvement, but subsequent relapse nearly always occurs and this method is rarely worth the time and trouble involved.

Indications for operation

Operation should be delayed if possible in children, as it is bound to interfere with subsequent growth of the toe. Nor should operation be undertaken unless there is room for the toe to lie between the first and third toes.

(3) Operative technique

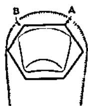
Incision

By making two curved incisions over the dorsum of the proximal interphalangeal joint, an ellipse of skin is excised, together with the corn, a portion of the extensor tendon and capsule of the joint. The point of a narrow scalpel

making the distal portion of the incision the knife should be inserted obliquely, in order to counteract the tendency for this part of the skin flap to curl in when the wound is being closed.

Removal of nail-bed

A periosteal elevator or narrow osteotome is now inserted into this part of the incision and thrust under the nail-bed to elevate it from the phalanx. The whole of the contents of the hexagon are now removed, leaving the bone bare and clean. Finally, the lateral roots of the nail-bed are carefully excised. These roots extend round the base of the phalanx as far as its plantar surface. It is most important to excise them completely.



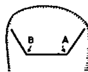





Fig. 84.—Incision and method of closure for radical excision of nail-bed.

Partial excision of phalanx

The terminal half of the phalanx is now dissected out and excised. This permits the plantar flap of skin and subcutaneous tissue to be brought up, completely closing the wound as shown in Fig. 84.

The V-shaped parts of the hexagonal incision at the sides of the toe not only facilitate the closure of the incision but also result in giving the toe a good shape, and give a good exposure for the removal of the nail-bed.

4. MORTON'S METATARSALGIA

(1) Definition and aetiology

Nature of condition

This condition is quite distinct from the generalized pain in the region of the metatarsal heads that occurs in cases of anterior foot strain. It consists in a very localized painful spot just distal to the line of the metatarsal heads and usually just to the medial side of the fourth head.

It is due to the development of a small fibro-neuroma on the digital nerve to the third cleft just before it divides into its two branches. Occasionally it develops on one of the branches just distal to the point of division or on one of the other digital nerves.

The pain is of a sharp, excruciating variety, shooting into the affected toes, and it occurs whenever the neuroma is subjected to pressure, as is liable to happen when walking upon uneven ground.

(2) Operative technique

Although relief from symptoms can sometimes be afforded by the provision of a metatarsal support, the condition can be finally cured only by operation.

Incision

A small longitudinal incision is made in the sole of the foot in the line of the affected nerve. The nerve can best be found just proximal to the metatarsal heads where it emerges from the deep fascia. A portion of the nerve, including the neuroma, is then excised.

Excision of portion of digital nerve

The proximal end of the nerve should be cut flush with the deep fascia, while pulling on it so that it retracts into the deeper layers of the foot.

as it will go. The toe is now released and will be found to lie limply in place. The skin incision is closed as a "Y" so that there is no tension upon the skin which might tend to redisplace the toe.

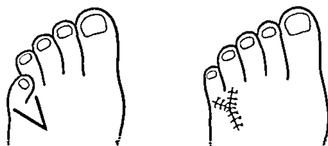


FIG. 82.—Incision for correction of varus fifth toe.

3. INGROWING TOE-NAIL

(1) Aetiology

Nature of condition

Causes of pain

The *symptoms of ingrowing toe-nail are due to the growth of the* nail edge into the skin fold. It nearly always affects the great toe and may be due to a variety of causes. In most cases the condition is primarily due to the pressure of shoes upon the side of the nail. The predisposing causes are:

(a) A badly shaped nail which has too great a transverse curvature.

(b) Hypertrophy of the skin folds at the edge of the nail.

(c) *Onychogryphosis—a horny condition of the nail which* develops after injury to the nail-bed.

(d) Careless trimming of the nail.

(2) Operative technique

Most cases can be successfully dealt with by a competent chiropodist. If conservative measures fail, operative measures are indicated. Three types of operation are commonly practised:



FIG. 83.—To show crescentic slice of skin and subcutaneous tissues removed for ingrowing toe-nail.

(*a*) *Plastic operation on skin fold*

An elliptical portion of skin and subcutaneous tissue is excised as shown in Fig. 83. Suture of the skin edges now draws the remains of the skin *fold away from the nail. This operation* should be performed at both sides of the nail if necessary. It is a simple and effective measure for those cases in which there is no deformity of the nail itself.

(*b*) *Partial removal of nail and nail-bed*

In this operation a slice of the edge of the nail, together with the nail-bed and the skin fold, is excised. This is liable to lead to deformity and irregular growth of the nail subsequently and is not recommended.

(*c*) *Radical excision of nail-bed*

This operation is indicated for all cases in which there is deformity of the nail itself and conservative measures have failed to give relief.

Incision

A hexagonal incision is made round the nail as shown in Fig. 84. When

FRACTURES, DISLOCATIONS, FRACTURE-DISLOCATIONS AND ALLIED INJURIES

By F. W. HOLDSWORTH, M.Chir., F.R.C.S.
Orthopaedic Surgeon, Sheffield Royal Infirmary and Sheffield Children's Hospital; Lecturer in Orthopaedic Surgery, University of Sheffield

PART I
INTRODUCTORY

1. FRACTURES

(1) General

157.] The principles of the treatment of fractures are well recognized and generally accepted by surgeons. It is well, however, to lay stress on certain points.

(2) Treatment

The object of treatment of a fracture is to assist the natural process of repair. The fragments must be replaced in as accurate a position as is possible, so that the final remodelling will restore the proper anatomy of the bone.

The fragments must not be allowed to move upon each other for, especially during the first few weeks of repair, movement will inevitably destroy the young granulation tissue joining the fragments and delay union. Even in the later stages of repair, excessive movement will delay consolidation of the fracture so that, in general, immobilization must continue until union is clinically sound.

Perfect restoration of function in a limb depends not only upon union of the fracture in good position, but also upon healing of the soft-tissue damage and restoration of mobility. Since prolonged immobilization of joints and soft tissue often leads to intractable stiffness, only the amount of fixation necessary to immobilize the fracture should be used and the remaining joints should be freely exercised from the beginning.

In certain fractures it is not always advisable to attempt reduction of the displacement. The manipulations necessary to restore anatomical position may be so damaging as to result in grave loss of mobility, whereas the original displacement may not interfere with function.

BIBLIOGRAPHY AND REFERENCES

Betts, L. O. (1940). *Med. J. Aust.*, **1**, 514.
Brockman, E. P. (1930). *Congenital Club Foot* (Talipes equinovarus). Bristol; Wright.
— (1937). *Brit. med. J.*, **2**, 572.
Browne, D. (1936). *Proc. R. Soc. Med.*, 29, 1409.
— (1937). *Brit. med. J.*, 2, 570.
Dunn, N. (1930). *J. Bone Jt Surg.*, **12**, 299.
Fitzgerald, F. P., and Seddon, H. J. (1937). *Brit. J. Surg.*, **25**, 283.
Girdlestone, G. R., and Spooner, H. J. (1937). *J. Bone Jt Surg.*, **19**, 30.
Keller, W. L. (1904). *N.Y. med. J.*, **80**, 741.
Lambrinudi, C. (1927). *Brit. J. Surg.*, **15**, 193.
— (1933). *Proc. R. Soc. Med.*, 26, 788.
Mayo, C. H. (1908). *Ann. Surg.*, **48**, 300.
McElvinny, R. T. (1943). *J. Bone Jt Surg.*, **25**, 675.

[References to other titles are given under Foot—Surgery of in the Index Volume. The subject of Diseases and Deformities of Foot is also dealt with under the heading of Foot, Diseases and Deformities in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 412.]

usually be obtained by manipulation but occasionally the interposition of soft tissues, *especially the capsule of the joint or tendons, prevents reduction.* In such cases the joint must be exposed by operation and the obstruction to reduction removed.

After reduction, although the position is usually stable, the joint should be immobilized to allow the soft tissues to heal. Immobilization should not be *continued too long, however, as this will lead to limitation of movement by* adhesions and capsular contraction. Generally 2–3 weeks' immobilization, followed by gentle increasing exercise, will allow healing to occur without limitation of movement. . *Adhesions, and capsula contraction*

In old unreduced dislocations the soft tissues are firmly contracted and usually prevent manipulative reduction. Moreover the articular cartilages are so damaged that, if reduction is obtained, degenerative arthritis results with permanent restriction of movement.

Usually reduction by manipulation can be performed up to 3–4 weeks after the occurrence of the dislocation. Dislocations of longer standing cannot be reduced, as a rule, except by open operation. Operative reduction in the large joints, such as the hip and shoulder, is a formidable procedure and careful selection of the cases is necessary. In old patients, and sometimes in young patients, too, it may be better to leave the dislocation unreduced, and to allow a false joint to develop in the dislocated position. Each case must be judged individually. *Selection of cases for operative reduction*

PART II
UPPER LIMB

Methods of reduction

When the displacement present is such that reduction is necessary, then two methods are available—manipulation and operation.

(i) *Manipulation.*—This is by far the safer method. Most fractures can be reduced safely and easily by manual manipulation with the patient anaesthetized so as to relax the muscles. In shaft fractures the first manipulation is traction in the axis of the limb to overcome shortening, followed by direct pressure or angulation to overcome the remaining deformities. In articular fractures the manipulation necessary varies with the individual case. The detailed type of manipulation necessary for the reduction of individual fractures is described fully in the following pages.

(ii) *Operative reduction.*—When manipulative reduction fails, and in cases in which the deformity is such that reduction is necessary for the restoration of function, some operative procedure is justifiable. This may consist in the introduction of pins or nails to increase traction, the division of muscles, or the full exposure of the fracture with direct manipulation of the fragments. Whatever operative method is used, however, it must be remembered that the patient is thereby exposed to the risks of infection and that infection of the fracture may lead to gross loss of function. Operation, therefore, should be undertaken only when the indications are clear. It must not be done purely to provide a satisfactory x-ray picture of reduction and never by an inexperienced surgeon or in an unsatisfactory theatre.

Risk of infection

(3) Radiography

Skiagrams must be taken of every fracture in at least two planes at right angles to each other. Without such skiagrams an accurate estimate of the deformity cannot be made and, consequently, an intelligent attack upon the problem of reduction and immobilization is impossible. After reduction, the position of the fragments must be checked by similar skiagrams, and controls are advisable at intervals throughout the period of immobilization, particularly in those cases in which re-displacement is possible. Finally, union must be checked by skiagrams. There should be no exception to these rules.

2. DISLOCATIONS

(1) General

Indirect violence or the direct violence of a fall upon a joint may result in dislocation of the joint. Dislocation of a joint is always accompanied by tearing of the capsule. The dislocated bone escapes from the joint cavity through a hole in the capsule and thus lies outside the joint. All dislocations are associated with damage to surrounding soft tissues, especially to the muscles attached to the bone near the articulation.

Soft-tissue damage

Dislocations are extremely painful and result in complete loss of function in the affected joint, which shows obvious deformity and swelling. The swelling may be so great as to obscure the deformity, even in large joints such as the shoulder. *Therefore, careful radiological examination of all injured joints should be made.*

(2) Treatment

Dislocations should be reduced as soon as possible. Relief of pain is immediate when the bones are restored to their anatomical position. Reduction can

(1) Dislocation of the sterno-clavicular joint

Reduction and fixation

The clavicle may be displaced forwards, downwards, upwards or (rarely) backwards. Reduction of the forward and upward displacement is easily effected by pulling the shoulders back and directly manipulating the displaced sternal end. Reduction is maintained by a figure-of-eight bandage round the axillae which holds the shoulders back, a full arm-sling on the affected side, and a broad strip of adhesive strapping over a pad of felt placed upon the sternal end of the bone. *Displacement*

(2) Recurrence of dislocation

Re-displacement frequently occurs. Fortunately recurrence of the dislocation usually results in the clavicle becoming stable in the dislocated position, and a full range of painless shoulder movement is obtained without any disability other than a slight deformity. If, however, the inner end of the clavicle slips in and out on moving the arm, with resultant pain and disability, then operative fixation by fascial suture as described by Bankart (1938b) should be undertaken, or 1 inch of the inner end of the clavicle should be removed. *Re-displacement*

(a) Operative fixation of Bankart

The front of the joint is exposed by a horizontal incision and the periosteum is stripped from the end of the clavicle and the upper end of the sternum. Two drill holes are made, from before backwards, through the inner end of the clavicle and also through the upper end of the sternum near the joint line. The ends of a long strip of fascia, taken from the thigh, are passed one through each hole in the clavicle, brought behind the joint and through the holes in the sternum and there knotted firmly, the knot being fixed by silk sutures. The free ends are then used to reinforce the torn anterior capsule. After the operation the arm is bandaged to the side for a month.

(b) Resection of inner end of clavicle

Through a horizontal incision the inner end of the bone is exposed and 1–1½ inches are removed. No attempt is made to reconstitute the ligaments. Resection is a much simpler procedure and the resulting function is excellent, though the inner end of the shortened clavicle may be somewhat unsightly. *Function excellent*

(3) Acromio-clavicular dislocation

This is a much more common injury. The degree of displacement depends upon whether or not the conoid and trapezoid ligaments are ruptured. If they are intact, then the displacement is small and there may be no abnormality besides tenderness over the joint and pain on abduction of the arm. If, however, the ligaments are ruptured, the bones are widely displaced and the acromial end of the clavicle can be easily palpated riding high above the level of the acromion (Fig. 85). *Displacement*

Reduction and fixation

The displacement is easily reduced by lifting the arm together with the scapula, and pressing downwards upon the outer end of the clavicle. The position is maintained by strapping. The forearm is held at a right angle by a collar-and-cuff sling, one pad of adhesive felt is placed over the outer end of

1. CLAVICLE

158.] The clavicle acts as a strut from the scapula to the sternum and as such is liable to injury from falls upon the outstretched hand or upon the point of the shoulder. As a result of such violence the clavicle may dislocate at the sternal or clavicular end or it may fracture.

the outer fragment is displaced downwards and inwards by the weight of the arm and the inner fragment upwards by the pull of the sternomastoid. There is often considerable overriding of the fragments. In the outer-third fractures the displacement resembles that of acromio-clavicular dislocation, and depends upon whether or not the conoid and trapezoid ligaments have been ruptured. *Displacement*

(*a*) *Middle-third fractures*

(i) *Treatment.*—The displacement is reduced by forcibly drawing back the shoulders against the operator's knee, which is placed against the patient's back. The shoulders are then fixed in this position by a figure-of-eight bandage

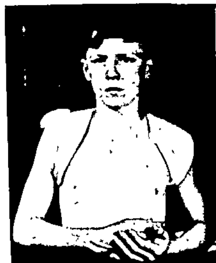



FIG. 87.—Fixation for fracture of the clavicle. The figure-of-eight bandage passes round each axilla over a large pad of cotton-wool. The sling is omitted for clearness.

passing over a large pad of cotton-wool placed in each axilla (Fig. 87). The affected arm is then supported in a triangular sling. The bandage is adjusted every third or fourth day and fixation is maintained for 3 weeks, during which time the hand and forearm are exercised regularly. Firm union usually occurs in 3 weeks but frequently there is considerable visible deformity, both from displacement of the fragments and from excessive callus. Fortunately malalignment and excessive callus in no way interfere with function, which is rapidly restored by free exercise when union is sound. *Visible deformity*

To obtain a perfect cosmetic result is a greater problem since far more accurate immobilization is necessary. This can be secured best by nursing the patient flat in bed with a hard sand-bag between the shoulders and the affected arm fixed in abduction by traction. This position is maintained for 3–4 weeks.

(ii) *Non-union.*—Non-union of fractures of the middle third of the clavicle is unusual. When it does occur, it is frequently painless and heavy work can be performed with little or no disability. Sometimes, however, movements of the shoulder are painful and, in such cases, the fracture is exposed and the ends freshened and fixed in position by an onlay graft applied to the posterior surface of the bone and fixed by vitallium screws. The arm and shoulders are then immobilized in a full arm spica plaster until union is sound.

the clavicle and another pad over the point of the elbow. The arm is then forced upwards, and the clavicle downwards, by layers of broad adhesive

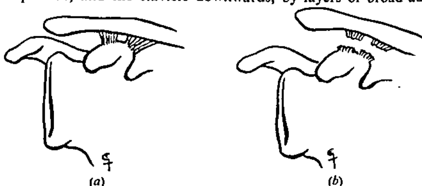


FIG. 85.—Diagrams showing acromio-clavicular dislocation: (a) with intact conoid and trapezoid ligaments—little displacement; (b) with rupture of conoid and trapezoid ligaments—marked displacement of the clavicle.

strapping encircling the two (Fig. 86). Fixation is maintained for 4 weeks, during which time the fingers and wrist are exercised constantly. Re-displacement frequently occurs.



FIG. 86.—Fixation for acromio-clavicular dislocation. The adhesive strapping passes from the elbow over the outer end of the clavicle. The sling is omitted.

(4) Unreduced dislocation of the acromio-clavicular joint

Frequently the dislocation does not produce any disability and heavy work is possible with the clavicle fully displaced. Occasionally, however, there is persistent pain from the unstable clavicle and, in such cases, resection of 1 inch of the outer end of the clavicle, with no attempt to reconstruct the joint or the coraco-clavicular ligaments, gives the most satisfactory result (Mumford, 1941). The bone is resected through a straight incision, the soft tissues are stitched together, and the arm is placed in a sling until the wound has healed, this being followed by active movements of the shoulder.

(5) Fractures of the clavicle

The clavicle is usually fractured in the middle third by a fall upon the outstretched hand or upon the point of the shoulder. More rarely the bone fractures between the acromio-clavicular joint and the attachments of the conoid and trapezoid ligaments. In the more common middle-third fractures,

(4) Treatment

The displaced head must be restored to its normal position by manipulation.

(a) Hippocrates's manipulation

The patient lies flat on his back and the dislocation is reduced by firm traction upon the arm against the counter-traction of the surgeon's unbooted foot in the axilla. The foot is used gently to lever the head into position and

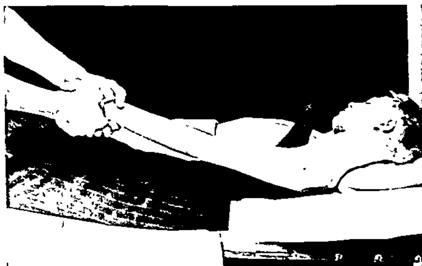


Fig. 88.—Hippocrates's method of reduction of dislocation of the shoulder. Traction is applied against the counter-pressure of the unbooted foot in the axilla.

the arm is externally rotated. If carried out gently, this manoeuvre is simple and safe (Fig. 88).

(b) Kocher's manipulation

With the patient lying down, the surgeon flexes the elbow and grasps it with his right hand and the wrist with his left. Traction is maintained throughout the manipulation by pulling with the right hand. The arm is gently and smoothly externally rotated by carrying the wrist away from the body. When external rotation is complete, the elbow is adducted and finally the arm internally rotated so that the hand lies on the opposite shoulder. It is essential that the external rotation should be carried out *gently*. Forcible jerky movements may fracture the neck of the humerus. *Importance of gentle rotation*

(5) After-treatment

The arm is supported in a sling for 3 weeks. Finger and wrist movements are practised throughout. At the end of this time shoulder movements, gradually increasing in extent, are encouraged.

(6) Complications

The dislocation may be accompanied by avulsion of the neighbouring muscles, especially those of the supraspinatus group, by fracture of the great tuberosity of the humerus, or by damage to branches of the brachial plexus.

(b) Outer-third fractures

Fractures of the outer third of the clavicle are treated as acromio-clavicular dislocations.

2. SCAPULA

(1) Fracture of body of scapula

Fracture of the body of the scapula is usually due to direct violence. Displacement of the fragments is unimportant.

Treatment

Early movement of the shoulder is the most important part of treatment, especially in patients over 45 years of age. The arm is supported in a sling for 2–3 weeks and gentle movement of the shoulder started at once. The range of movement allowed is gradually increased and full exercise encouraged when the sling is discarded.

(2) Fractures of neck and glenoid

Fractures of the neck and the glenoid are caused by falls either upon the outstretched hand or directly upon the shoulder. The glenoid is often considerably displaced downwards and may be comminuted. The displacement results in flattening of the contour of the shoulder, as in dislocations of the joint, from which it may be distinguished by the relatively free mobility of the arm in fracture of the scapula.

Treatment

The displacement is unimportant, especially in elderly patients, as full functional recovery can occur even with gross displacement. As in fractures of the body of the scapula, early movement of the shoulder is essential. The arm is supported in a sling and gentle movements are started at once. The sling should be retained for 4–5 weeks and then more energetic movements should be encouraged.

3. DISLOCATION OF THE SHOULDER

(1) Aetiology

Dislocation of the shoulder is common because of the small shallow articular facet of the scapula and the lax capsule of the joint. Sudden violence to the arm, especially in abduction, is the usual cause of the dislocation.

(2) Displacement

The head of the humerus leaves the socket through a tear in the inferior part of the capsule and then passes medially to lie beneath the coracoid process. Rarely, the head passes backwards to lie in the subspinous fossa and, in very rare cases, may remain below the glenoid with the arm fixed in abduction (*luxatio erecta*).

(3) Diagnosis

The shoulder loses its rounded contour and the acromion process is unduly prominent. The elbow is held in abduction and cannot be brought to the side without causing considerable pain. The head of the humerus cannot be felt by palpation immediately below the acromion process, as in the normal shoulder, but frequently can be located below the coracoid process.

recurrent dislocation, the head of the humerus shows a large defect in its postero-medial part, making re-dislocation easier in a position of external rotation should the anterior capsule be slack.

Dislocation usually recurs, often with great frequency, resulting in considerable disability.

Treatment

Many operations have been described for this condition. Only two have proved successful in any large series of cases.

Nicola's operation

(i) *Transplant of the long-tendon of the biceps* (Nicola, 1934).—A 5-inch incision is made from the coracoid process along the delto-pectoral groove. The cephalic vein is retracted medially and the muscles are separated to expose the bicipital groove. The groove is opened and the tendon divided at its lower end. A drill hole is made from the lower end of the bicipital groove through the head of the humerus, emerging in the articular cartilage about ½–¾ inch from its edge. The proximal end of the divided tendon is passed through the groove and the two tendon ends are stitched together. The lower end of the transverse humeral ligament is then stitched to the tendon in the distal part of the bicipital groove and the wound closed. The arm is supported by the side in a sling for 4–5 weeks and then gradually mobilized. The tendon becomes firmly fixed in the groove and acts as a short ligament binding the head to the glenoid and preventing re-dislocation.

A simple modification of the Nicola operation is described by Roberts (1934). Instead of dividing the biceps tendon, the groove is opened and the tendon lifted out. With a chisel the compact bone of the floor of the groove is then turned inwards as a flap and a deep groove is cut in the cancellous bone of the head thus exposed. The tendon is placed in this groove and the bone flap stitched back in place over it. After-treatment is as for the Nicola operation.

Bankart's operation

(ii) *Bankart's operation* (Bankart, 1938a).—The patient lies on his back with a small sand-bag between the shoulders and with the arm at the side, the elbow being supported by another sand-bag. A 5-inch incision is made from above the coracoid down in the line of the delto-pectoral groove. The cephalic vein is exposed and retracted medially. The deltoid and pectoralis major are separated and retracted, exposing the pectoralis minor and its attachments to the coracoid process. The tip of the coracoid is separated with a chisel and the muscle retracted downwards exposing the subscapularis. The arm is then fully externally rotated and the subscapular muscle, thus put on the stretch, is divided close to its attachment. The muscle is retracted medially. The whole anterior capsule of the joint is thus exposed together with the anterior margin of the glenoid and the neck of the scapula. The capsule is then divided parallel to the glenoid margin and the head of the humerus pulled away from the glenoid; the separated labrum can then be seen. The anterior margin of the glenoid is roughened with a chisel and the cut surface of the capsule is placed in contact with the rough area by internal rotation of the arm and there fixed by sutures through drill holes in the bone or by staples of stainless steel driven into the neck of the scapula. The subscapularis is then stitched and the divided coracoid replaced and fixed by sutures through soft tissue. The skin is sutured and the arm bandaged to the side for 1 month, after which time free exercise is allowed.

(*a*) *Supraspinatus rupture* (Fig. 89)

Inability to abduct the arm

Failure to recognize rupture of the supraspinatus tendon may result in prolonged inability to abduct the arm. The tear can be recognized by the inability to abduct the arm immediately after reduction of the dislocation. In such a case, after reduction, the arm must be immobilized in abduction, either upon a frame or in plaster, until the arm can be lifted from the splint.



FIG. 89.—Subcoracoid dislocation of the shoulder with rupture of the supraspinatus muscle.

Recovery of abduction can be made more certain by suture of the torn tendon 2–3 weeks after the dislocation. The shoulder is opened by a sabre-cut incision, running from behind forwards across the point of the shoulder. The deltoid is separated from its attachments to the clavicle and spine of the scapula, thus exposing the torn supraspinatus tendon. The tendon is then sutured with silk and the wound closed. After operation the arm is supported in abduction for 6–8 weeks.

(*b*) *Fracture of the great tuberosity* (Fig. 90)

Fracture of the great tuberosity can also be recognized by the immediate absence of the power of abduction. Skiagrams will reveal whether the great tuberosity is displaced or not. If displacement is negligible the after-treatment is as for uncomplicated dislocations. If, however, the tuberosity is separated, the arm must be held in abduction for 5–6 weeks or the power of abduction may never return.



FIG. 90.—Subcoracoid dislocation with avulsion of the great tuberosity which is retracted by the pull of the supraspinatus.

(*c*) *Nerve injury*

Involvement of axillary nerve

Nerve injury is uncommon. The axillary nerve is most commonly involved, with resulting paralysis of the deltoid and loss of the power of abduction. The diagnosis can be made by palpating the deltoid when the patient attempts to abduct the arm. Lack of contraction in the muscle is easily detected. In such cases the arm should be supported in abduction until the muscle regains its power.

Paralysis of other branches of the plexus is rare and should be treated as are similar peripheral nerve paralyses from other causes.

Exercise.—In all cases it is extremely important that the hand and forearm should be exercised throughout treatment. Lack of such exercise has often resulted in permanent stiffness of the fingers after a simple dislocation of the shoulder.

(7) Recurrent dislocation of the shoulder

Recurrent dislocation of the shoulder is usually the result of a fall upon the elbow with the humerus externally rotated and the point of the elbow behind the plane of the body. The head of the humerus is driven directly forwards, tearing the labrum from its attachment to the glenoid rim. After reduction of the dislocation the defect resulting from detachment of the labrum may persist, either as a large gap between the labrum and the glenoid or as an abnormally lax anterior capsule of the joint. Moreover, in many cases of

Possible persistence of defect

and frequently separation of the great tuberosity in these fractures (Fig. 92). In such cases manipulation frequently fails to reduce the deformity and the decision has to be made whether to leave the angulation or to reduce the deformity by open operation.

Treatment

In older patients open reduction is inadvisable. Better results are obtained by employing a collar-and-cuff sling and permitting early movements of the shoulder, but in young patients, with gross displacement, operative reduction should be undertaken.

Open reduction

The fracture is exposed through an anterior incision extending downwards from the coracoid process. The groove between the deltoid and the pectoralis



Fig. 92.—Abduction fracture of the neck of the humerus. There is also a fracture of the glenoid.

major is exposed, *together with the cephalic vein. The vein is retracted medi*ally and the muscles are separated, so exposing the coracoid process and the pectoralis minor. The tip of the coracoid is then separated by an osteotome and turned down together with the pectoralis minor, thus exposing the head of the humerus and the anterior capsule of the shoulder. Wider exposure is obtained by detaching the origin of the deltoid from the outer third of the clavicle. With the fracture exposed, the head of the humerus is levered into position. Internal fixation is usually unnecessary but the fragments can be made more stable by drilling the head of the humerus and passing the long tendon of the biceps through the drill hole as in the Nicola operation for recurrent dislocation of the shoulder (*see* page 175). After reduction of the fracture the coracoid is re-sutured, the deltoid reattached to the clavicle and the skin sutured. The arm should be supported in a collar-and-cuff sling for 6–8 weeks and gentle swinging exercises started after the first 3 weeks. Finger, wrist and elbow exercises should be practised throughout.

Swinging exercises

Haemostasis essential

This operation is difficult. Great care must be taken at all stages to stop bleeding, otherwise the field is obscured and accurate fixation of the capsule made impossible. When correctly performed, however, it results in a powerful, stable shoulder and is, therefore, the operation of choice.

4. HUMERUS

(1) Upper end: neck

Fractures of the neck of the humerus are common. The fragments are frequently impacted and the displacement is small.

(a) *Fractures: impacted without displacement*

Immobilization unnecessary

In such cases reduction and immobilization are unnecessary. The arm is supported in a collar-and-cuff sling and active movement of the shoulder, forearm and hand should be encouraged from the beginning. The sling is discarded after 5 weeks and more active movements are then carried out. Such treatment restores excellent use to the shoulder, though in older patients there is usually slight permanent restriction of abduction and rotation.



FIG. 91.—Adduction fracture of the neck of the humerus in a child.

(b) *Fractures: impacted with displacement*

Fractures of the neck of the humerus with displacement are divided into *adduction* fractures and *abduction* fractures, both of which are caused by falls upon the arm. In the majority of these fractures the fragments are firmly impacted.

Displacement

(i) *Adduction fractures.*—There is outward angulation at the site of fracture, the shaft being adducted in relation to the head and often impacted on the inner side. This fracture, occurring in the surgical neck, is common in children (Fig. 91).

Treatment

If the displacement is not great, the fracture is treated by supporting the arm in a sling and permitting early movement. With considerable displacement, however, and especially in young people, union with adduction of the shaft will result in loss of abduction. Reduction of the displacement is, therefore, necessary. This is accomplished by traction on the abducted arm. After reduction the arm can often be brought to the side and treated in a collar-and-cuff sling. If the position is unstable after reduction, it is advisable to apply an abduction splint for 4–6 weeks.

Risk of loss of abduction

Displacement

(ii) *Abduction fractures.*—There is inward angulation at the fracture site

fossa it is necessary to separate the shaft from the scapula by steady, powerful traction upon the arm, and then to replace the head by direct manipulation. The traction can be applied with the arms either by the side or in abduction.

Hippocrates's method.—Traction is applied against the counter-traction of the surgeon's unbooted foot in the axilla, as in the reduction of simple dislocations. The upper end of the shaft is levered outwards, using the foot as a fulcrum, and the arm rotated outwards (Fig. 88).



FIG. 95.—Fracture-dislocation of the shoulder.

Traction in abduction may be applied by Böhler's method or by the method suggested by Patrick.

(ii) *Böhler's method.*—Skeletal traction is applied by an olecranon pin with the arm fixed in the Böhler shoulder frame (Böhler, 1935a). When the shaft is pulled well away from the glenoid, the head is replaced by direct manipulation (Fig. 96).

(iii) *Patrick's method.*—In this method, adhesive extensions are applied to the arm and the patient is placed supine upon the floor. The extensions are attached to an overhead pulley and the patient is lifted from the floor by powerful traction. The arm automatically lies in the correct position of abduction and the head is then replaced by direct manipulation (Fig. 97).

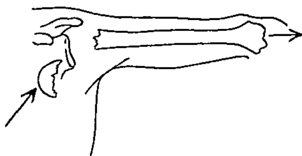


FIG. 96.—Bohler's method of reduction of fracture-dislocation of the shoulder. The shaft is pulled away from the glenoid by powerful traction in a frame and the head is then replaced by manipulation.

Danger of traction

These methods using powerful traction are dangerous. The axillary vessels and branches of the brachial plexus are in danger of grave damage if traction is too powerful.

Reduction by manipulation frequently fails. This is due to the difficulty of returning the head through a hole in the capsule and of feeling the head in the subcoracoid region and thus controlling the direct replacement.

The results of open operation are so disappointing that it should be avoided, except in cases of gross displacement.

(iii) *Abduction fractures with separation.*—Occasionally there is wide separation of the fragments in abduction fractures. The shaft is displaced below the head (Fig. 93). In such cases continuous traction in abduction is necessary. This is best carried out by weight extension with the patient lying in bed on his back. Traction is maintained for 5–6 weeks.

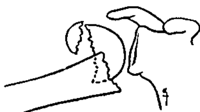


FIG. 93.—Abduction fracture of the neck of the humerus. Note separation of the shaft with displacement.

(*c*) *Fractures of the great tuberosity*

Fractures of the great tuberosity are common. They are the result either of direct violence to the great tuberosity of the humerus, producing a fissured fracture without displacement, or of avulsions of the tuberosity by sudden contraction of the supraspinatus muscle, producing separation of the tuberosity with considerable displacement.

(i) *Fractures without displacement* (Fig. 94 (a)).—The arm is supported in a collar-and-cuff sling and early shoulder movements are ordered. The sling is retained for 3–4 weeks, movements being gradually increased.

(ii) *Fractures with displacement* (Fig. 94 (b)).—In these cases the displaced tuberosity can be replaced in position by placing the arm upon an abduction

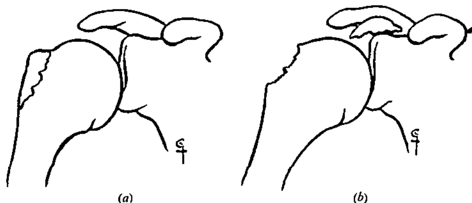


FIG. 94.—Fracture of the great tuberosity of the humerus: (*a*) without displacement; (*b*) with displacement.

splint in external rotation and forward flexion so that the hand is in front of the face. Attempts to abduct the arm from the splint should be started after 8 weeks and the splint discarded when active abduction can raise the arm from the splint.

(*d*) *Fracture-dislocation of the shoulder*

Displacement This is the most serious of all shoulder injuries. The dislocation is subcoracoid and the humerus fractured at the neck. The head of the bone lies beneath the coracoid, often almost upside down, and the fragments are widely displaced (Fig. 95).

Reduction is extremely difficult. In order to replace the head in the glenoid

(c) Treatment

Reduction by longitudinal traction is easy. It is unnecessary to have accurate reduction as union occurs rapidly *and full function* is the usual result, even with shortening and angulation.

Immobilization

All fractures of the shaft are best treated by simple *immobilization with short* plaster slabs or gutter splints, the arm being supported in a collar-and-cuff sling (Fig. 98). Union is usually sound in 6 weeks. Occasionally union is slow and, in such cases, the arm should be immobilized in a plaster shoulder spica until there is clinical and radiological evidence of union (Fig. 99).



FIG. 98.—U-slab for humerus.

Danger of traction

Fractures of the shaft should not be treated by continuous traction or on an abduction frame as the distraction of the fragments so produced may result in delayed union or established non-union.

Complications.—The musculo-spiral paralysis, which is sometimes associated with fractures of the mid-shaft of the humerus, usually recovers without operative intervention in 6–8 weeks. During this time the wrist and metacarpo-phalangeal joints must be supported in a cock-up splint. If there is no recovery of the nerve in this time, and when the fracture is united, the nerve should be explored.



FIG. 99.—Shoulder spica plaster for fracture of the shaft of the humerus.

(3) Lower end

(a) Supracondylar and transcondylar fractures

(i) *Aetiology.*—Fractures of the lower end of the humerus are very common in children. They are produced by over-extension or by over-flexion of the elbow (Watson-Jones, 1943a).

(ii) *Displacement.*—The extension fracture is the most common. The line of fracture runs from in front upwards and backwards and the lower fragment is displaced backwards and upwards. In the more uncomm

If manipulative reduction fails, the head should be replaced by open reduction.

(iv) *Open reduction.*—The shoulder is exposed by the anterior incision described on page 177. After retracting the pectoralis minor downwards, it is necessary to divide the attachment of the subscapularis to the shaft of the humerus in order to expose the dislocated head of the bone. When full exposure has been obtained, the head is gently levered back into position, great care being taken to preserve any remaining soft-tissue attachments. Additional stability is obtained by passing the long tendon of the biceps through a drill hole in the head. The operation is one of considerable difficulty and danger, and should not be undertaken in old people. In such patients, if manipulative reduction fails, the dislocation should be left, the arm supported in a collar-and-cuff sling and gentle movements started at once. A surprising degree of useful function often results.

Operation contra-indicated in old people



FIG. 97.—Patrick's method of reduction of fracture-dislocation of the shoulder by traction and direct manipulation.

Occasionally the displaced head presses upon branches of the brachial plexus and great pain results. In such cases in old people the head of the humerus should be removed.

Avascular necrosis

Avascular necrosis of the head of the humerus, with resulting arthritis of the shoulder, often occurs after fracture-dislocation and, in such cases, if pain is severe, it is often advisable to perform an arthrodesis of the joint.

(2) Upper end: shaft

Spiral or transverse fractures

Fractures of the shaft of the humerus are either spiral or transverse.

(a) *Aetiology*

Spiral fractures are produced by rotational strain and transverse fractures by either direct violence or angulating strains.

(b) *Displacement*

The fragments are usually angulated and overlapped by muscle pull.

(*b*) *Intercondylar fractures*

(i) *Aetiology*.—These fractures are due to direct falls upon the point of the elbow. The olecranon process is driven upwards and splits the condyles apart. They are separated from each other and frequently comminuted.

(ii) *Displacement*.—The lower fragments are usually also displaced forwards (Eastwood, 1937).

(iii) *Treatment*.—The fracture is reduced by traction upon the arm and direct lateral compression by the operator's hands forcing the condyles together. This position is maintained by a full arm plaster at 15–30° *below* right-angled flexion. The fragments will displace if the elbow is flexed more and, if immobilized in full extension, limitation of flexion will be the ultimate result. The arm is slung from the neck by a collar-and-cuff sling. The plaster is retained for 6 weeks and followed by active movements of the elbow.

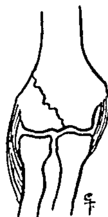


FIG. 101.—Line of fracture in separation of the capitellum. (*For purposes of clarity the olecranon has been omitted in this and subsequent figures.*)

Open operation contra-indicated

As in supracondylar fractures, transcondylar fractures should never be reduced by open operation as great restriction of elbow movement results. Even if the fragments remain displaced, eventual function is better after conservative treatment. When conservative treatment, followed by a prolonged period of free exercise, results in gross restriction of movement, then arthroplasty of the joint should be considered.



FIG. 102.—Separation of the capitellum. The fragment is rotated by the pull of the extensor muscles.

(*c*) *Separation of the capitellum*

In children from 5 to 15 years, falls upon the outstretched hand with the forearm forced into varus may separate the epiphysis of the capitellum. The fracture line runs through the lower end of the humerus and through the lateral portion of the trochlea, thus separating the capitellum together with a portion of the shaft and of the trochlea (Fig. 101). As the greater part of the separated fragment is cartilaginous, care must be taken in interpreting the skiagrams.

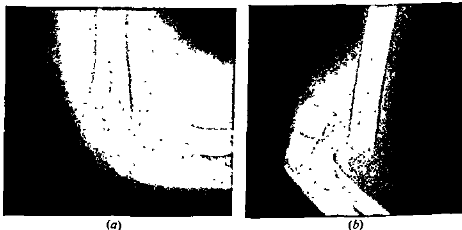
(i) *Displacement*.—If the injury results from severe violence, the separated fragment is pulled downwards and rotated outwards by the pull of the common extensor attachment (Fig. 102). Sometimes the rotation is such that the fractured surface points outwards and downwards.

Injury to brachial artery

fracture, the fracture line runs from before downwards and backwards and the lower fragment is displaced forwards and upwards (Fig. 100). In both types there is considerable danger of injury to the brachial artery.

Accurate reduction in both the antero-posterior and lateral planes is essential in these fractures as any remaining displacement is not corrected by subsequent growth and will result in ugly deformity of the arm and limitation of elbow movement.

(iii) *Treatment.*—The elbow is usually so swollen that palpation of the bones is impossible. Manipulation must, therefore, be controlled by x-ray examination whilst the patient is under the anaesthetic and the surgeon must be



(*a*) (*b*)

FIG. 100.—Supracondylar fracture of the humerus: (*a*) flexion type; (*b*) extension type.

prepared to repeat the manipulation until accurate reduction is obtained.

Extension fractures

The surgeon grasps the wrist firmly with one hand and maintains a steady pull on the arm. Whilst the traction is maintained, the lower fragment is directly pushed forwards with the fingers of the opposite hand and, at the same time, the elbow is flexed to 45° beyond the right angle. Lateral displacement is then corrected by direct pressure with the surgeon's hands, the arm being held in flexion by an assistant. A plaster slab is then applied along the dorsum of the arm and forearm and the limb is suspended from the neck by a collar-and-cuff sling. Care must be taken to see that the elbow is not in such acute flexion as to endanger the circulation. The fixation is maintained for 3 weeks and is then replaced by a simple sling and gentle elbow exercises are commenced. The sling is discarded in 2–3 weeks.

Circulation impeded by acute flexion

Flexion fractures

When the lower fragment is displaced forwards, manipulative reduction is carried out in a similar manner, except that the direct pressure pushes the lower fragment backwards. The position is best maintained by immobilization in extension by a plaster splint for 3 weeks, followed by a sling at right angles for 2–3 weeks. This position should be adopted for children only. If the elbow is immobilized in extension for 3 weeks in the adult there is danger of subsequent loss of flexion. In adults, therefore, the elbow should be immobilized at right angles by a dorsal slab for 3 weeks, followed by the use of a sling and active movements.

Immobilization in extension for children

Immobilization at right angles for adults

Operative reduction is not recommended in supracondylar fractures, for it is very frequently followed by permanent gross restriction of movement.

and the wrist dorsiflexed to tighten the flexors. If the manipulation is successful, the small fragment can be felt to slip out of the joint. Failure of manipulation leaves no alternative to open operation.

Open operation

The inner side of the joint is exposed by a straight incision, the ulnar nerve is identified, and the fragment is pulled out of the joint by a hook passed round the flexor muscles, which can be seen passing into the joint. Anterior transposition of the ulnar nerve should be carried out at the same time.

(*e*) *Dislocation of the elbow*

Displacement

The most common dislocation is that of the radius and ulna backwards (Fig. 104). More rarely the displacement is medial or lateral and, occasionally, the bones are displaced forwards. The latter dislocation is nearly always complicated by fracture of the olecranon process of the ulna.



Fig. 104.—Posterior dislocation of the elbow.

(i) *Backward dislocations.*—These dislocations are most frequently unassociated with fracture of any of the bones. Occasionally, however, the coronoid process of the ulna is fractured.

Reduction

With the elbow flexed to a right angle, forcible steady traction is applied in the direction of the arm and gentle forward pressure applied to the olecranon. The displaced radius and ulna usually slip back into place easily. The elbow is then supported in flexion in a collar-and-cuff sling for 3 weeks, after which gentle active movements are begun.

When there is associated fracture of the coronoid process, if the fragment is small, the fracture can be neglected, but if it is large, the reduction is unstable and, in such cases, the joint must be immobilized in a full arm plaster with the elbow at right angles for 6–8 weeks.

Reduction

(ii) *Lateral dislocations.*—Reduction of a lateral dislocation is carried out as for a posterior dislocation except that, after extension has been applied, lateral pressure is exerted upon the displaced bones. The after-treatment is as for a posterior dislocation.

(iii) *Anterior dislocations.*—An anterior dislocation is almost always associated with fracture of the olecranon process, which remains retracted by the triceps behind the humerus.

Traction in extension

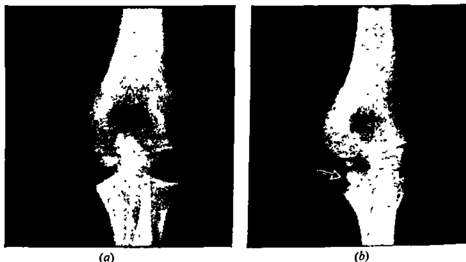
Reduction is effected by traction *in extension.* The arm is immobilized at 30° below the right angle in a full arm plaster and, 10 days later, the olecranon fracture is exposed and sutured or screwed into position. The plaster is

(ii) *Treatment.*—When displacement is not severe the fragment can be replaced by manipulation (Wilson, 1936). With the patient fully anaesthetized, the elbow is fully extended and forcibly adducted. This manoeuvre opens the outer side of the joint and provides room for replacement of the fragment, which is pushed into place by direct manipulation.

Manipulation

Operative replacement

This manoeuvre frequently fails when displacement is severe and, in such cases, operative replacement is necessary. The fragment is exposed by a short incision. Great care is taken not to disturb the muscle attachments to the fragment as, if these are stripped, avascular necrosis will occur, with a resulting stiff elbow. The fragment is directly manipulated into position by traction



(*a*) (*b*)

Fig. 103.—Separation of the internal epicondyle: (*a*) downward displacement; (*b*) the fragment trapped in the joint.

upon the muscle attachment, and by rotation. With accurate reduction, internal fixation is unnecessary (Speed and Macey, 1933). The arm is immobilized in a plaster, extending from the axilla to the metacarpal heads with the elbow in flexion, and the wrist in extension to relax the extensor muscles. The plaster is retained for 6 weeks.

(*d*) *Separation of the internal epicondyle*

(i) *Aetiology.*—A fall upon the outstretched hand, with the elbow forced into valgus, results in separation of the internal epicondyle, which may be pulled down by the common flexor origin (Fig. 103 (a)). If the violence is severe, the internal lateral ligament of the elbow is ruptured and the small avulsed fragment may be trapped in the joint (Fig. 103 (b)). In such cases there is often damage to the ulnar nerve. Unless the fragment is trapped in the joint, replacement is unnecessary. Full function will be restored with the fragment widely displaced.

Ulnar nerve damage

(ii) *Treatment.*—The arm is supported in a collar-and-cuff sling for 3 weeks, followed by increasingly active movements.

Manipulation

When the fragment is caught in the joint it can occasionally be released by manipulation (Watson-Jones, 1943b; Roberts, 1934). With the arm in full extension, the forearm is forcibly abducted to open the inner side of the joint

All that is necessary is to apply a full arm plaster with the elbow at right angles for 6 weeks, followed by active movements.

(*b*) *With separation*

If the aponeurosis is torn, the pull of the triceps results in wide separation of the fragments, which cannot always be brought together even by full extension of the elbow (Fig. 105). In such cases open reduction and fixation is necessary.

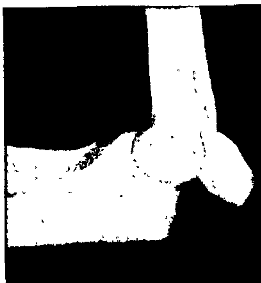


Fig. 105.—Fracture of the olecranon with rupture of the aponeurosis and wide separation of the fragments.

Open reduction

The fracture is exposed by a slightly curved longitudinal incision. The fragments are cleared of blood clot and the olecranon process is drawn down with a sharp hook. The fragment is fixed to the shaft by a vitallium screw, which is placed obliquely, so as to engage the cortex of the shaft or, alternatively, one drill hole is made transversely through the olecranon and another transversely through the upper end of the shaft and the olecranon tied down by strong catgut passed through the holes. After suture the arm is immobilized in plaster with the elbow in flexion for 8 weeks. If a screw is used and is accurately placed, the fixation is so firm that plaster is unnecessary (Fig. 106). The arm is supported by a collar-and-cuff sling at right angles for 10–14 days and then movement is allowed.



Fig. 106.—Fracture of the olecranon reduced and the fragments fixed with a vitallium screw. Note that the screw engages the cortex of the shaft of the ulna.

(3) Comminuted fractures of the olecranon

Fixation of fragments difficult

With comminution, fixation of the fragments is difficult or impossible and excision of the olecranon gives more satisfactory results.

replaced and retained for 6–8 weeks, after which free exercise is begun (*see* Fracture of the Olecranon).

Myositis ossificans

In all dislocations of the elbow there is damage to the insertion of the brachialis, with consequent danger of myositis ossificans. All manipulations must be gentle so that this danger is not increased.

(*f*) *Dislocation of the elbow with fracture of the head of the radius*

The dislocation is reduced and the fracture of the head of the radius then treated as described below.

(*g*) *Physiotherapy after injuries in the region of the elbow joint*

Associated capsular and muscular damage

Injuries to the elbow joint are associated with capsular and muscular damage, which frequently results in restriction of movement at the joint, either from capsular contraction or from new bone formation as the result of myositis ossificans at the insertion of the brachialis muscle.

Both capsular contraction and myositis ossificans are increased by forced passive movements and by massage. *After injuries to the elbow, movement should be restored by active exercise only.* No passive movement or massage should be allowed. Failure to observe this rule will often result in permanent gross restriction of movement (Jones, 1904 and 1932).

5. RADIUS AND ULNA

(1) Fracture of the radial head

(*a*) *Aetiology*

The radial head is fractured by a fall upon the outstretched hand. The head of the bone may be split without displacement of the fragments, a section of the head may be separated and displaced downwards, or the whole head may be comminuted.

(*b*) *Treatment*

If there is no displacement or the displacement is small, conservative treatment gives the best results. The arm is supported with the elbow in flexion in a collar-and-cuff sling for 3 weeks. Pronation and supination are practised after the first few days and free exercises allowed after 3 weeks.

When there is gross displacement, or the head is comminuted, excision of the whole radial head offers the best chance of restoration of full function.

Excision of the radial head.—With the elbow flexed, the radial head is palpated and exposed through a straight incision. The neck is cleared and the periosteum stripped down to the level of the orbicular ligament. The neck is then cleanly divided by a sharp osteotome and the head removed, together with all the fragments. After removal the fragments should be fitted together to make sure that the whole head has been removed. The arm is supported in a collar-and-cuff sling for 3 weeks as in the conservative treatment of this fracture.

(2) Fracture of the olecranon

(*a*) *Without separation*

The olecranon process may be fractured by direct violence without rupture of the triceps aponeurosis and, in such cases, there is no separation of the fragments.

arm. Prolonged traction is often necessary before the displacement is corrected (Böhler, 1935c). Lateral displacement may also require direct manipulation whilst the traction is maintained. After reduction, and with the traction still in operation, a full arm plaster is applied from the axilla to the metacarpal heads (Fig. 108). The plaster is accurately moulded and traction maintained until it is set, when the sling is removed and the plaster completed over the arm. The plaster is removed after 10–12 weeks. Check skiagrams are necessary, particularly in the first 2 weeks, for re-displacement is frequent, even with well-moulded plasters. *Check skiagrams*

For this reason open reduction is often advisable and should be undertaken without hesitation by those trained in non-touch technique.

(ii) *Open reduction.*—The ulna is exposed by an incision over its subcutaneous border. The radius is exposed in its lower two-thirds by an incision over

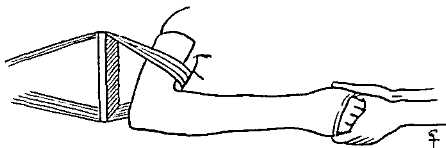


FIG. 108.—Method of manipulative reduction of fractures of the radius and ulna: plaster applied with traction still in force.

the antero-lateral aspect. The brachio-radialis is retracted backwards. In the upper third the anterior approach is safest. The incision is made to the outer side of the biceps tendon which is traced down to the bicipital tuberosity. From there the supinator is peeled off the bone, carrying the dorsal interosseous nerve with it. Lateral incisions endanger the nerve as it passes through the supinator. The exposed fractures are manipulated into place with long-handled forceps. In rare cases the reduction is stable without internal fixation and the wounds can be closed and a full arm plaster applied. In most cases, however, one or other fracture is unstable and internal fixation is necessary. This is best effected by a 4-screwed vitallium plate on both bones. The screws should transfix both cortices and hold the fractures firm (Fig. 109). In plating both bones the ulna should be dealt with first as some difficulty may be experienced in reducing the fracture of the ulna after fixation of the radius. After both bones have been fixed with plates, splinting or plaster is unnecessary (Burns and Young, 1944). Movements can be started at once and union is usually sound in 3 months. The plates should be removed when radiological union is sound. *Internal fixation*

(7) Non-union of fractures of the lower end of the ulna and upper third of the radius

The stability of the elbow depends upon the articulation between the humerus and the ulna. The stability of the wrist depends upon the articulation between the carpal bones and the radius (Fig. 110). Non-union of fractures of the lower third of the ulna is common and is due to inadequate or too short

Excision of the olecranon

The fracture is exposed by a curved incision and the fragments are removed. The aponeurosis of the triceps is then sutured to the upper end of the ulna, which must be drilled, using fascial sutures if necessary. After the operation it is unnecessary to immobilize the joint for longer than 10–14 days.

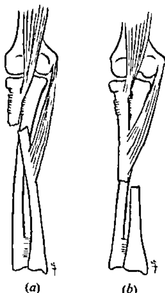


FIG. 107.—Fractures of the forearm: (*a*) in the upper third the upper fragment of the radius is supinated by the supinator and the lower fragment pronated by the pronator; (*b*) in fractures below the insertion of the pronator radii teres the upper fragment is in the mid-position.

(4) Fractures of the shafts of both bones

(a) Importance of accurate reduction

Accurate reduction of fractures of the forearm bones is extremely important. Any remaining rotatory displacement or angulation will inevitably lead to loss of pronation or supination. Even with accurate reduction, fibrosis of the interosseous membrane, resulting from the organization of exudate, may limit rotation by shortening the arc through which the radius rotates round the ulna (Patrick, 1946).

(b) Displacement

The displacement of the fragments is usually complicated because of the intricate action of the forearm muscles (Böhler, 1935b). In general, in fractures of the upper third of the radius, *the upper fragment is supinated; in fractures of* the radius below the insertion of the pronator teres, the upper fragment is in the mid-position, whereas the lower fragment is always pronated (Fig. 107). Thus in fractures of the upper third, immobilization must be in supination and, in fractures below the insertion of the pronator teres, immobilization must be in the mid-position.

Detection of rotational deformity

Rotational deformity is often undetected in the skiagram. It can best be recognized by noting a sudden change in the apparent width of the interosseous space at the level of the fracture. It cannot be detected by noting the position of the joints.

(5) Greenstick fractures

Treatment

These fractures are common in children. The displacement, if any, is easily corrected by direct gentle manipulation. The forearm is immobilized in a full arm plaster for 3 weeks and then free exercise is allowed.

(6) Fractures with displacement

Treatment

These fractures may be treated by manipulative reduction and plaster fixation or by open operation and fixation.

(i) *Manipulative reduction.*—The fracture is reduced by strong and sustained traction on the fingers, against counter-traction by a sling surrounding the

immobilization. It is, however, unimportant and is best treated by resection of 1 inch of the ulnar shaft below the fracture.

Non-union of fractures of the upper third of the radius is not so common, but this does not lead to loss of function *unless associated with lower radio-ulnar dislocation* (*see* page 192).

(8) Fracture of the upper third of the ulna and dislocation of the radial head (Monteggia's fracture)

(a) Displacement

This is a most difficult injury to treat. Two types of displacement occur.

(i) *Flexion Monteggia.*—In this injury, fracture of the upper third of the ulna occurs with backward dislocation of the radius. The ulna is angled backwards. This displacement occurs in about 10 per cent of the cases.

(ii) *Extension Monteggia.*—Fracture of the upper third of the ulna is associated with forward dislocation of the radius. The ulna is angled forwards. This displacement occurs in about 90 per cent of the cases (Fig. 111).

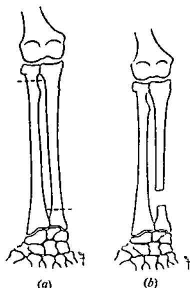


FIG. 110.—(*a*) The radial head can be removed without affecting the stability of the elbow—the ulnar head without affecting the stability of the hand. (*b*) Amount of bone removed for ununited fracture of the lower ulnar shaft (Baldwin's operation).

(b) Treatment

In both types reduction is difficult and maintenance of reduction even more difficult. Only in children can reduction be satisfactorily maintained (Naylor, 1942). In adults open operation with internal fixation of the fractured ulna is essential. The ulna is best fixed with a 4-screwed vitallium plate, the screws transfixing both cortices.

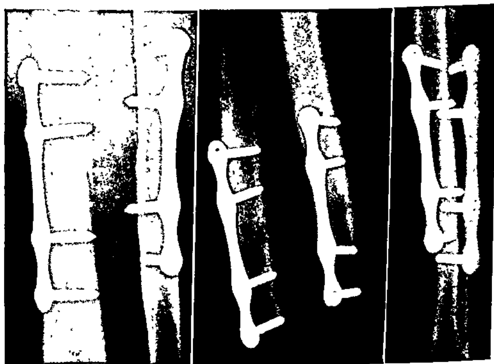
(i) *Reduction of flexion fractures.*—The fracture and dislocation of the head of the radius are reduced by extension of the elbow, traction and direct manipulation over the radial head. The arm is held in extension and the ulnar fracture exposed and fixed by a plate. After the plating the arm is fixed in plaster with the elbow at right angles for 3 months. Although this fracture-dislocation is usually stable if immobilized in extension, prolonged fixation of the elbow in this position in the adult will lead to loss of flexion.

(ii) *Reduction of extension fractures.*—In extension fractures the fracture and dislocation are reduced by traction on the forearm with the elbow at right angles and direct pressure on the radial head. The fracture of the ulna is exposed and fixed with a vitallium plate and 4 screws. A full arm plaster is then applied with the elbow at right angles and this is retained for 3 months. In these fractures operative reduction of the radial head or early excision of the head of the radius should not be undertaken. Both measures will result in stiffness of the elbow.

Avoidance of elbow [illegible]



(*a*)



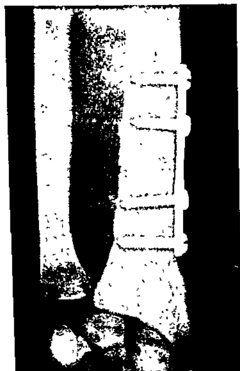
(*b*) (*c*)

Fig. 109.—(*a*) Fracture of both bones of the forearm. (*b*) Post-operative skiagram. The fracture is fixed by plates and screws. Note that the screws transfix both cortices. (*c*) The same case 4 months later. The fractures are firmly united.

This should be done without hesitation as internal fixation of the radius is then easy and wrist function returns to normal (Fig. 113).



(a)



(b)

FIG. 112.—(*a*) Fracture of the radius with subluxation of the lower radio-ulnar joint (Galeazzi's fracture). (*b*) The same case—fixation effected by a 4-screwed plate. Note the alteration in position in the radio-ulnar joint.



FIG. 113.—Excision of the head of the ulna. The stability of the wrist is not affected.

(10) Fracture of the lower end of the radius (Colles's fracture)

(*a*) *Displacement*

This fracture is extremely common and is usually caused by a fall upon the palm. The bone is broken within an inch of the lower end and the fragments

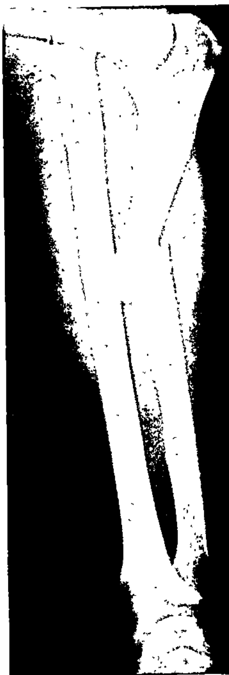


FIG. 111.—Monteggia's fracture with forward dislocation of the radius. The ulna is angled forwards. The opposite displacement, that is, backward dislocation of the radius and backward angulation of the ulna, occurs in only 10 per cent of the cases.

(c) Old fractures

Even with the best treatment, the result of this fracture in the adult is bad. In old fractures, in the adult, with dislocation of the radial head and angulation of the ulna, the displaced radial head should be removed. Only in children in whom there is failure of closed reduction should operative replacement of the radial head be considered.

(9) Fracture of the radius with dislocation of the lower radio-ulnar joint (Galeazzi's fracture)

(a) Displacement

Fractures of the shaft of the radius in the middle and lower third are usually associated with dislocation of the lower radio-ulnar joint. The dislocation is frequently missed unless it is appreciated that fracture of the shaft of the radius with any displacement of the fragments, and without fracture of the ulna, must be associated with a dislocation between the radius and ulna (Fig. 112). In such cases, therefore, the radiographs of the radio-ulnar joints must be examined.

(b) Treatment

Unstable reduction

The fracture is easily reduced by traction upon the forearm but these fractures are frequently unstable and re-displacement occurs in plaster. Internal fixation is, therefore, advisable by plating the fracture of the radius with a 4-screwed vitallium plate. After plating it is advisable to immobilize the forearm in a full arm cast for 3–4 weeks. External fixation can then be discarded and free exercise allowed. This method is safer than maintaining position by transfixation wires fixed in the plaster.

(c) Old fractures

In fracture-dislocations of this type more than 4 weeks old, reduction of the deformity of the radius is often impossible, even at open operation, unless the head of the ulna is removed first.

(12) Smith's fracture

Occasionally in fractures of the lower end of the radius, the lower fragment is displaced forwards, with forward subluxation of the wrist. Such cases are rare (Fig. 115).

Treatment

The fracture is reduced by traction upon the hand and by firm pressure, with one hand pushing the lower fragment backwards against the counter-pressure of the other hand upon the back of the upper fragment. Immobilization is as for a Colles's fracture. It is advisable, in order to prevent re-displacement, to maintain pressure until the plaster is set.



FIG. 115.—Smith's fracture.

(13) Separation of the lower radial epiphysis

Falls upon the ball of the thumb in children result in separation of the lower radial epiphysis, which is displaced backwards and to the radial side as is the lower fragment in Colles's fractures (Fig. 116).

Reduction is carried out in a similar manner, as also is immobilization. *Considerable force is necessary for accurate reduction. Fortunately, in young children, remoulding occurs even if reduction is incomplete.*

(14) Fracture of the radial styloid

The radial styloid process is frequently fractured by forcible dorsiflexion of the hand. The scaphoid is driven against the radial styloid and the fracture line



FIG. 116.—Separation of the lower radial epiphysis.

enters the wrist joint at the level of the proximal pole of the scaphoid. The fragment is displaced outwards and must be pushed back into place so as to restore the joint outline.

are impacted. There is frequently comminution of the lower fragment. The fragment is displaced dorsally and to the radial side and is also rotated dorsally. As a result of the rotation, the lower articular facet, which in the intact radius faces forwards at an angle of 30° to the shaft, may point backwards. With any degree of displacement there is damage to the lower radio-ulnar joint with rupture of the triangular fibrocartilage, and often avulsion of the ulnar styloid process. The fracture is easily detected clinically by the typical dinner-fork deformity.

Accurate reduction of the displacement is essential, otherwise persistent ugly deformity remains.

(*b*) *Treatment*

Manipulative reduction

For a right Colles's fracture, with the patient anaesthetized, the surgeon grasps the hand with his right hand as if shaking hands. The fragments are disimpacted by firm traction. The backward and outward displacements are then reduced by direct pressure with the thumb of the left hand, using the fingers for counter-pressure on the upper fragment. The reduction is facilitated by rotating the hand into pronation. Traction is then maintained by an assistant and the fracture immobilized in a close-fitting plaster, extending from the elbow to the metacarpal heads. The plaster must be most accurately moulded round the radial styloid and the first metacarpal but should not be carried into the palm so as to restrict finger movements (Fig. 114). When the lower fragment is comminuted, the tendency to re-displacement can be minimized by immobilization with the hand in ulnar deviation. Immobilization is continued for 5 weeks.



Fig. 114.—Colles's fracture. Plaster fixation—the plaster extending round the first metacarpal but not restricting finger or thumb movements.

Use of arm

Throughout this time it is essential that full shoulder, elbow and particularly finger movements should be practised continuously. The arm should not be carried in a sling but should be used as far as possible normally. Unless these exercises are conscientiously carried out, permanent stiffness of the fingers will result in a crippled hand.

(11) Mal-united Colles's fracture

Resection of the ulnar head

Although the appearance of the wrist is ugly, mal-union of this fracture is usually associated with good function, provided that finger exercises have been practised throughout. The main disability is loss of supination due to disorganization of the radio-ulnar joint. In such cases the appearance of the wrist can be greatly improved and supination restored by resection of the ulnar head.

(12) Smith's fracture

Occasionally in fractures of the lower end of the radius, the lower fragment is displaced forwards, with forward subluxation of the wrist. Such cases are rare (Fig. 115).

Treatment

The fracture is reduced by traction upon the hand and by firm pressure, with one hand pushing the lower fragment backwards against the counter-pressure of the other hand upon the back of the upper fragment. Immobilization is as for a Colles's fracture. It is advisable, in order to prevent re-displacement, to maintain pressure until the plaster is set.



Fig. 115.—Smith's fracture.

(13) Separation of the lower radial epiphysis

Falls upon the ball of the thumb in children result in separation of the lower radial epiphysis, which is displaced backwards and to the radial side as is the lower fragment in Colles's fractures (Fig. 116).

Reduction is carried out in a similar manner, as also is immobilization. Considerable force is necessary for accurate reduction. Fortunately, in young children, remoulding occurs even if reduction is incomplete.

(14) Fracture of the radial styloid

The radial styloid process is frequently fractured by forcible dorsiflexion of the hand. The scaphoid is driven against the radial styloid and the fracture line



Fig. 116.—Separation of the lower radial epiphysis.

enters the wrist joint at the level of the proximal pole of the scaphoid. The fragment is displaced outwards and must be pushed back into place so as to restore the joint outline.

Treatment

Traction is applied to the hand and the fragment pushed into place by firm pressure of the surgeon's hands placed one on each side of the wrist. Immobilization is as for a Colles's fracture as described above.

6. FRACTURES OF THE CARPAL BONES AND DISLOCATIONS AT THE WRIST

(1) Carpal scaphoid

(a) Diagnosis

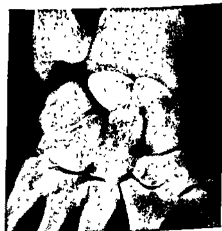
Fractures of the carpal scaphoid are frequently overlooked. It cannot be too strongly emphasized that after every injury to the wrist in which there is tenderness on the radial side of the joint, careful examination must be made of skiagrams of the wrist taken in 3 planes. Even then a fine crack in the scaphoid is often missed and skiagrams must be repeated 4–5 days later, when the fracture is much more easily detected owing to decalcification of the bone. Only if a second skiagram fails to reveal a fracture is a diagnosis of a sprained wrist justifiable.



(*a*)



(*b*)



(*c*)

FIG. 117.—Fractures of (*a*) the tuberosity of the scaphoid; (*b*) the waist of the scaphoid; (*c*) the proximal pole of the scaphoid.

(b) Types of fracture

The scaphoid may be fractured in 3 places (Fig. 117):

Early union

(i) *The tuberosity may be separated.*—Here the fracture is extra-articular and union occurs rapidly. The wrist should be supported in a dorsal plaster splint for 3–4 weeks, after which time free exercise is allowed.

(ii) *Fractures of the waist.*—This is the common fracture. The fracture line is intra-articular and there is often displacement between the fragments. Union may be slow. If displacement is present, it must be reduced by traction in *Union slow*

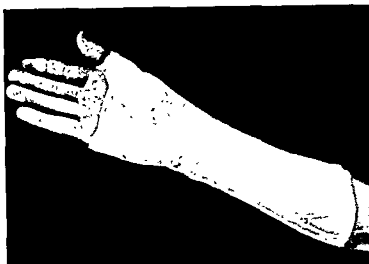


FIG. 118.—Plaster for immobilization of fractures of the scaphoid. The metacarpo-phalangeal joint of the thumb is included. The cast is sufficiently far back in the palm to allow of free finger movement.

ulnar deviation, pressure upon the distal fragment and impaction by swinging the wrist over to radial deviation. The wrist is then immobilized in a full plaster, which includes the metacarpo-phalangeal joint of the thumb (Fig. 118). The cast must not extend high enough into the palm to obstruct finger movements. Immobilization is continued until union is complete as seen radiologically. This usually occurs in 8–12 weeks but may take much longer.



FIG. 119.—Fracture of the proximal pole of the scaphoid. The density of the proximal fragment shows that this portion of the bone is avascular.

(iii) *Fractures of the proximal pole.*—In one-third of these fractures the proximal fragment is deprived of its blood supply and undergoes avascular necrosis. The fracture is treated as are fractures of the waist of the bone but, in the presence of avascular necrosis, immobilization may have to be continued for 12 or even 18 months (Fig. 119). *Avascular necrosis*

Even after prolonged immobilization union is frequently not obtained and degenerative arthritis subsequently occurs. Therefore, in proximal pole fractures, in which there is radiological evidence of avascular necrosis, excision of the small proximal fragment is justified. The bone is easily removed through a *Excision justified*

short dorsal incision. The wrist is immobilized for 3–4 weeks after the operation. Excision of the fragment usually results in a painless wrist, though there is frequently some permanent restriction of movement.

(2) Old ununited fractures of the scaphoid

Attempts to obtain union of the fracture by drilling or bone grafting should not be made as the results are unsatisfactory. Frequently the function is good



(*a*)



(*b*)

FIG. 120.—(*a*) Transcarpal dislocation. The lunate remains attached to the radius and the remainder of the carpus is dislocated backwards. (*b*) Transcarpal dislocation. The scaphoid is also fractured here.

except for heavy work and, in such cases, the fracture is best left alone. If, however, there is much pain, due usually to degenerative arthritis of the wrist, either the scaphoid should be removed or, better, the wrist ankylosed by arthrodesis.

Degenerative arthritis

(3) Dislocations at the wrist

(*a*) *Radio-carpal dislocation*

Dislocations of the radio-carpal joint are uncommon. The proximal row of carpal bones may be displaced backwards or forwards and to the radial or ulnar side. Frequently the dislocation is compound and is associated with fractures of the radial or ulnar styloid processes or with the margin of the articular facet of the radius.

Reduction is easily accomplished by traction in the axis of the limb and, if *Reduction* necessary, by direct pressure. *After reduction the wrist is immobilized by a* plaster dorsal slab for 6–8 weeks. The result is usually excellent.

(b) *Transcarpal dislocation*

This is a much more common injury. The lunate remains attached to the radius and the remainder of the carpus *is dislocated backwards (Fig. 120).* Frequently the scaphoid and triquetrum are fractured and the portions adjacent to the lunate remain in position (Fig. 121). The injury is caused by over-dorsiflexion of the hand.

Early reduction easy

Reduction is easy up to 14 days after the dislocation. Manual traction combined with flexion of the wrist and direct pressure over the lunate will result in replacement (Watson-Jones, 1929). After reduction the wrist *is immobilized in slight dorsi*flexion for 4–5 weeks, unless there is associated fracture of the scaphoid or triquetrum or of both, *in which case immobilization must be continued* until the fracture is united.

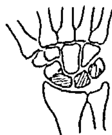


Fig. 121.—Line of separation in perilunar fracture-dislocation. The shaded portion remains in normal relationship to the radius and the rest of the carpus is dislocated backwards.

(c) *Isolated dislocation of the lunate*

Forcible dorsiflexion of the hand sometimes results in forward dislocation of the lunate, the other carpal bones remaining in proper relationship to the lower end of the radius.

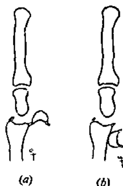


Fig. 122.—Isolated dislocation of the lunate: (a) the volar ligament is intact; (b) all ligamentous attachments are ruptured.

Two stages of the dislocation occur:

(i) The palmar ligament of the lunate is intact and the articular facet points towards the palm (Fig. 122 (a)).

In such cases reduction can easily be accomplished by traction, flexion and pressure with the thumb over the lunate. After reduction, the wrist *is immobilized for 3–4 weeks by a plaster slab.* There is no tendency to re-displacement if the wrist is kept in dorsiflexion.

(ii) All the ligamentous attachments of the lunate are torn and the bone is rotated through 180° and often displaced in front of the lower end of the radius. Pressure on the median nerve is common *Median nerve* in such cases (Fig. 122 (b)).

In such cases replacement of the bone is impossible by manipulation. Moreover, the bone, having been separated from its blood supply, inevitably shows avascular necrosis. In such cases *the correct treatment is early excision of the lunate* *Excision* through a straight volar incision.

Isolated dislocation *of other* carpal bones occurs rarely. *If attempts at* reduction fail, removal of the bone is indicated.



FIG. 123.—Fracture of the first metacarpal.

(4) Fractures of the metacarpals

(a) *First metacarpal*

Fracture of the base of the first metacarpal is the commonest injury to the metacarpals. The fracture may be associated with dislocation of the carpo-metacarpal joint.

(b) *Fractures not involving the joint*

The bone is usually angled to the radial side (Fig. 123).

Reduction and traction

Correction of the deformity by traction and direct pressure is easy. The fracture is stable and immobilization in a full wrist plaster for 4 weeks is all that is necessary.

(c) *Fracture-dislocation (Bennett's fracture)*

A small triangular fragment is separated from the metacarpal bone and remains in position whilst the rest of the bone is dislocated *proximally (Fig. 124).*

Reduction by traction on the abducted thumb and pressure over the metacarpal base is easy, but the reduction is unstable unless continuous traction is employed on the thumb in full abduction. This is obtained by strapping tapes or collodion gauze fastened to the thumb and tied to a metal splint incorporated in the plaster. Traction is maintained

Continuous traction

for 4 weeks. The tapes require constant adjustment to make sure the traction is continuously effective. Further immobilization is necessary for 2 weeks after the traction is removed, after which free exercise of the thumb is allowed. Even with perfect reduction and immobilization, the joint often remains painful for 5–6 months.



FIG. 124.—Fracture-dislocation of the first metacarpal (Bennett's fracture).

(d) *Fractures of the shafts of the metacarpals*

These fractures are either transverse or spiral and are the result of blows upon the hand. The greatest danger following the fracture is persistent stiffness of the fingers due to excessive immobilization. It is better to neglect the fracture and concentrate on mobility than to over-immobilize the fingers.

Treatment

In spiral fractures slight displacement is not important and union always occurs. Immobilization in a simple dorsal slab for 3 weeks is all that is necessary. The fingers are exercised throughout.

Non-union

Transverse fractures must be reduced as non-union frequently

occurs if the fracture is unreduced, and causes painful weakness of finger action. Reduction is accomplished by traction on the finger and direct pressure upon the fragments. If this manoeuvre fails, open reduction should be carried out. The fragments are exposed through a dorsal incision and the ends impacted. If the fracture is unstable, *it may be fixed by a small inlay* bone graft. The metacarpal is then immobilized by a dorsal slab for 4 weeks, finger action being practised throughout. *Open reduction*

(*c*) *Fractures of the neck of the metacarpal*

These fractures are common and are due to blows on the closed fist. The neck of the metacarpal is fractured and the head displaced forwards with wide angulation (Fig. 125 (a)). The fracture must be reduced otherwise deformity and limitation of extension of the finger will remain.

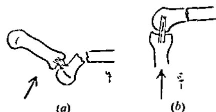


FIG. 125.—Fracture of the neck of the metacarpal. Reduction is not obtained by hyperextension of the metacarpophalangeal joint but by pressure along the flexed finger.

The deformity is overcome by pressure upon the flexed finger (Jahss, 1938) (Fig. 125 (b)). Following the manipulation the fracture is immobilized by a dorsal slab with a plaster or wire extension holding the affected finger in flexion. *Treatment*

(5) Fractures of the phalanges

(*a*) *Proximal and middle phalanges*

Fractures of the proximal and middle phalanges are common. The displacement is usually one of forward angulation and can be corrected by flexion of the finger.

The finger must be immobilized in flexion for 3–4 weeks by means of a plaster and incorporated metal splint (Fig. 126 (a)). If the fracture is unstable, continuous traction may be necessary. This can be obtained by tapes fixed to the finger by collodion and firmly tied to a hook incorporated in the plaster (Fig. 126 (b)). *Splint in flexion*

When immobilizing a finger in flexion, it must be remembered that in the flexed position each finger points to the tubercle of the scaphoid and must be immobilized in this position. Throughout the period of immobilization the uninjured fingers must be exercised.

(*b*) *Terminal phalanx*

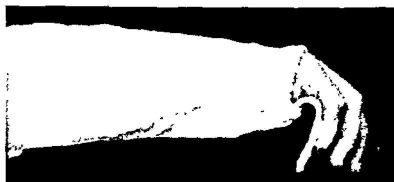
Comminuted fractures of the terminal phalanx only require the pressure of a firm bandage.

Mallet finger.—Avulsion of a small fragment from the phalanx with the extensor tendon attachment—a mallet finger—requires longer immobilization. The finger is immobilized with the proximal two joints fully flexed and the terminal joint extended. In this position the extensor tendon is slack and will re-attach to the phalanx. Immobilization should be continued for 6–8 weeks.

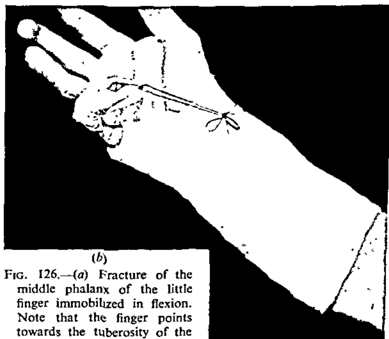
(6) Dislocation of the fingers and thumb

Metacarpo-phalangeal and interphalangeal dislocations are usually produced by hyperextension. The dislocation is reduced by traction and pressure

and the finger is immobilized in flexion for 3 weeks. Metacarpo-phalangeal dislocations of the thumb occur occasionally. The dislocation usually can be



(a)



(b)

FIG. 126.—(a) Fracture of the middle phalanx of the little finger immobilized in flexion. Note that the finger points towards the tuberosity of the scaphoid. (b) Unstable fracture of the phalanx immobilized in flexion with traction. The tapes are attached to a hook incorporated in the plaster.

reduced easily by long-axis traction but sometimes the metacarpal head is caught by the capsule or the tendon of the flexor longus pollicis. In such cases the dislocation must be reduced by open operation.

PART III
LOWER LIMB

1. DISLOCATION OF THE HIP

(1) Aetiology

159.] This is a relatively common injury. The hip is dislocated either by over-abduction of the joint or by a powerful force along the line of the femur, the hip being flexed to a right angle as when, in a motor crash, the dash-board is driven against the knees of the passenger.

Displacement

The head of the femur is displaced backwards (iliac dislocation) or forwards (pubic or obturator dislocation). In either case there is extensive muscle and



FIG. 127.—Reduction of a dislocation of the hip. The operator is pulling on the flexed knee whilst the assistant steadies the pelvis.

capsular damage and often fractures of the rim of the acetabulum or, more rarely, of a segment of the head of the femur.

(2) Physical signs

The physical signs are characteristic. When the femur is dislocated on to the ilium, the leg is held in flexion, adduction and marked internal rotation. In forward dislocation the leg is in flexion, abduction and external rotation. Skiagrams should always be taken to confirm the dislocation and to determine the presence or absence of an associated fracture.

(3) Treatment

(a) Reduction of dorsal dislocation

Reduction is relatively easy. For a dorsal dislocation the patient is placed supine upon a mattress on the floor and anaesthetized so as to obtain complete muscular relaxation. The pelvis is held firmly by an assistant, and the surgeon, standing over the affected leg, flexes the knee to a right angle and, with his hands behind the knee and the foot between his knees, lifts the femur back into place (Fig. 127).

Bigelow's method.—The classical method of Bigelow is an alternative. The patient is anaesthetized and the pelvis fixed by an assistant. The leg is flexed, abducted and then rolled down into extension, externally rotating as the leg is brought down.

(b) Reduction of anterior dislocation

For anterior dislocation the reverse movements of the Bigelow method above are used. The hip is flexed, adducted and rolled down into extension with internal rotation. The femur can be felt to slip into the acetabulum with a distinct thud and the reduction is stable, unless there is associated fracture of the acetabular margin.

The reduction should *always* be confirmed by antero-posterior and lateral skiagrams. *Confirmation of reduction*

Although the reduction is usually stable, the hip should be immobilized in a plaster spica for at least 8 weeks. This is essential as, since there is always extensive muscle and capsular damage, early movement is liable to produce extensive myositis ossificans. *Immobilization*

In some cases the extensive capsular damage may lead to an aseptic necrosis of the head of the femur. This is a serious complication as severe degenerative arthritis always follows and may require arthrodesis. *Necrosis of femoral head*

2. FRACTURE OF THE ACETABULUM

Fracture of the rim of the acetabulum is common in association with dislocation of the hip. The fracture does not usually interfere with reduction of the dislocation and, with the femur in place, the fragment usually falls into position. Small fragments do not interfere with the stability of reduction but large marginal fragments may do so. In such cases, continuous traction upon the leg is necessary to prevent re-displacement. An alternative to continuous traction is open reduction and fixation of the fragment with a bone peg or screw.

Fissured or comminuted fractures of the acetabulum may result from falls upon the great trochanter. Severe violence may drive the head of the femur through the base of the acetabulum into the pelvis (central dislocation of the hip). The injury is a serious one, for the damage to the articular cartilage is often severe even with fissured fractures and may result in progressive degenerative arthritis. *Fissured or comminuted fractures*

Treatment

Fissured fractures without displacement are best treated by continuous traction applied by strapping-extension to the leg, which is supported upon pillows. Gentle movements are practised throughout and the traction is maintained for 6–8 weeks.

When the acetabulum is comminuted and the head of the femur is displaced inwards, an attempt at reduction should be made. The head is pulled back into place by powerful traction applied through a pin transfixing the tibial tuberosity. An attempt to replace the fragment of the acetabulum may be made by open operation through an incision parallel to the inguinal ligament, and exposing the deep surface of the acetabulum extraperitoneally.

The patient is placed upon an orthopaedic table and powerful traction *Open reduction*

applied to the affected leg. The pelvic surface of the acetabulum is then exposed extraperitoneally through *an oblique incision above the inguinal* ligament. The fragments *are pushed into position.*



FIG. 128.—*Adduction fracture of the neck of the femur.* There is no impaction.

After operation, weight *traction is continued* through a tibial pin for 8–12 weeks.

Arthrodesis of hip

Frequently the fragments *cannot be replaced* and the hip remains painful *and stiff from degenerative* arthritis. In such cases *arthrodesis of the joint* is indicated.

3. FRACTURES OF THE FEMUR

(1) Neck

Violence to the hip, which in the young adult produces *dislocation* of the joint, in older patients results in fracture of the neck of the femur. The neck of *the femur fractures in one of two places:*

(a) Immediately below the head of the bone, the fracture line lying within *the hip joint* (subcapital or intracapsular fracture).

(b) At the junction of the neck with the trochanter (basal or extracapsular fracture).

(*a*) *Subcapital fractures*

Adduction fractures

In some 80 per cent of these cases there is an adduction deformity at the site of the fracture. The lower fragment *is also externally rotated. This* fracture is never impacted, although it often appears so in antero-posterior skiagrams. Lateral skiagrams show the wide separation (Fig. 128).



FIG. 129.—Abduction fracture of the neck of the femur.

Abduction fractures

The remaining 20 per cent of cases of subcapital fracture show an abduction deformity at the site of fracture and the lower fragment is not externally rotated. The fracture is nearly always impacted (Fig. 129).

(i) *Diagnosis.*—The diagnosis is easy in adduction fractures if it is

remembered that slight violence to the hip in an elderly patient may result in fracture of the neck of the femur. There is pain in the hip, inability to lift the leg and external rotation of the whole leg, together with $\frac{3}{4}$–1 inch of shortening.

In abduction fractures with firm impaction, the external rotation is absent and the leg can sometimes be lifted from the bed. In such cases the diagnosis depends upon the skiagram. *All elderly patients suffering violence to the hip should have skiagrams taken in both antero-posterior and lateral planes.*

Treatment

(ii) *Adduction fractures.*—In adduction fractures, although reduction is easy, the small upper fragment is not easy to control and, therefore, immobilization is difficult. The separated head of the femur has a poor blood supply; indeed, as a result of laceration of the capsule, the head may be altogether deprived of blood supply and undergo aseptic necrosis. In all cases, unless reduction is accurate and immobilization complete and prolonged, union will not occur. Satisfactory immobilization can be obtained in three ways:



Fig. 130.—Adduction fractures of the neck of the femur fixed by a Smith-Petersen nail: antero-posterior view.

Internal fixation by a Smith-Petersen nail. The two fragments are fixed by a tri-flanged nail introduced from below the trochanter along the neck into the head. The success of the operation depends upon the accuracy of the reduction and the correct placing of the nail in the centre of the neck and head of the femur.

Technique

The patient is anaesthetized either by gas and oxygen or by a spinal anaesthetic. The patient being fixed upon an orthopaedic table fitted with leg traction-bars, the fracture is reduced by flexion, abduction, internal rotation and moderate traction. The surface markings of the head and trochanter are marked by Michel's clips. The reduction is confirmed by x-ray examination made in two planes, antero-posterior and lateral (Fig. 130). The positions of Michel's clips relative to the head and trochanter are noted on the antero-posterior skiagram.

Use of guide wires

A guide wire is first introduced and its position checked by skiagrams. When the guide is in a satisfactory position, the canalized nail is driven over the wire to the correct depth and the wire is then withdrawn.

Many directors have been described to facilitate the introduction of the

guide wire but most are too complicated for practical use (Watson-Jones 1943c). The wire should be introduced by sense of touch alone, or one of the simple directors such as that of Hey Groves should be used. The Hey Groves director consists of two pins fixed rigidly to a cross-bar. The pins are of unequal length so that when one is driven from the front to bite into the femoral head and the other to bite into the trochanter, the canalized cross-bar of a third arm will direct the wire along the centre of the neck into the head (Fig. 131).

The Hey Groves director

The spikes of the Hey Groves guide are introduced down to the head and trochanter, using the clips as localizing points. A guide wire is then driven along the neck. The director is removed and the position of the guide wire checked by skiagrams. If the wire is not centrally placed, then a second wire is introduced, using the first as a guide and so on until a central position of the wire is obtained. A tri-flanged cannulated nail is then driven over the wire and into the femoral head. The length of nail necessary is calculated by subtracting the length of wire outside the femur from the known length of the whole wire. The position of the nail is finally checked by skiagrams.

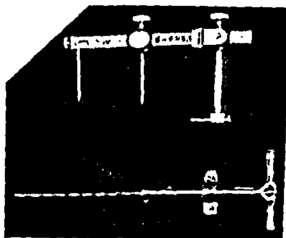


FIG. 131.—Hey Groves director and guide wire.

Fixation by nail is so firm that no external fixation is necessary. The patient should exercise the leg from the first but should not bear weight until radiological union is complete, usually after about 4 months.

Whitman's plaster. Fixation by plaster in abduction and full internal rotation was shown by Whitman to immobilize the fracture. The displacement is reduced and controlled by x-ray examination. The limb is then fixed in the position of abduction and full internal rotation by a plaster spica, extending from the opposite axilla to the toes on the affected side. The plaster is retained for 4–6 months until radiological union is sound. During this time the patient can be moved and allowed out of bed, but no shortening of the plaster is permissible until union can be demonstrated by skiagrams.

Subtrochanteric osteotomy of McMurray. One of the causes of non-union in subcapital fractures is the shearing strain caused by muscle action upon the oblique fracture line. Subtrochanteric osteotomy (McMurray, 1936), with inward displacement of the shaft, abolishes this strain with the result that union occurs (Fig. 132).

Operation

A vertical incision is made from the tip of the trochanter down the thigh and the femur is exposed. The shaft is divided with a sharp osteotome immediately below the lesser trochanter and the shaft is displaced inwards beneath the femoral head. The leg is then immobilized in a full hip spica plaster. The immobilization is maintained for 4 months.

The disadvantage of both the Whitman plaster and the McMurray osteotomy is that they necessitate immobilization of an old patient in a hip plaster for many weeks. Such immobilization may lead to hypostatic pneumonia and other complications. Internal fixation, though offering no greater chance of *Disadvantages*

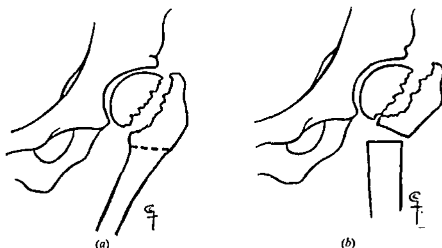


Fig. 132.—Subtrochanteric osteotomy in ununited fracture of the neck of the femur: (*a*) line of osteotomy; (*b*) displacement completed.

union, is free from such objections. The patient is mobile from the first and convalescence is easy and painless.

In very old feeble patients, subcapital fractures are best left untreated. After 2–3 weeks in bed the leg is exercised and the patient allowed to get up *Old and feeble patients*

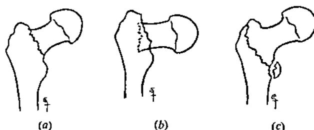


Fig. 133.—(*a*) Basal extracapsular fracture. (*b*) Basal fracture of the femoral neck with impaction of neck into trochanter. (*c*) Transtrochanteric fracture.

on crutches. Ultimate function is poor in such cases, for there may be as much as 3 inches of shortening with a resultant severe limp.

(iii) *Abduction fractures.*—These fractures are always firmly impacted and, if the hip is guarded by a short spica plaster for 6–8 weeks and weight bearing avoided for 3 months, union occurs and excellent function results. Such fractures should never be disimpacted.

(*b*) *Trochanteric fractures*

Fractures in the neighbourhood of the trochanter are more common than subcapital fractures. They are usually produced by falls upon the trochanter.

Three different types of fracture occur (Fig. 133):

(a) Basal extracapsular fracture of the femoral neck.

(b) Basal fracture of the neck with comminution of the trochanter.

(c) Transtrochanteric fracture.

In all cases there is apposition of large areas of bone and the blood supply of all the fragments is good. Union, therefore, always occurs whatever method of treatment is adopted.

(i) *Basal extracapsular fractures.*—The fracture line runs through the junction of the neck and the trochanter. Displacement is usually small, though there may be shortening and external rotation.

Treatment

These cases are best treated by fixation with the Smith-Petersen nail, introduced as in the case of the subcapital fractures. The results are excellent.

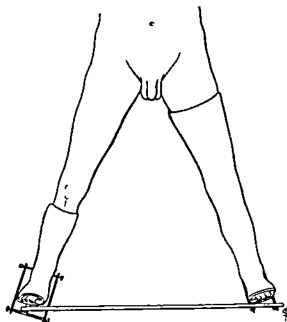


FIG. 134.—Well-leg traction. The sound leg is immobilized in a full leg plaster.

(ii) *Basal fractures with comminution of the trochanter.*—The fracture line runs through the base of the neck and the whole neck is driven deep into the trochanter. There is gross comminution of the trochanter with marked coxa vara and external rotation of the leg.

The displacement is reduced by traction, abduction and internal rotation. Position can be maintained either by continuous traction or by internal fixation.

Thomas's splint

Continuous traction. Adhesive tapes are fixed to the leg, which is suspended in a Thomas's splint slung from a Balkan beam. Weight extension is fixed to the tapes. The splint is swung into abduction and the opposite leg fixed to the side of the bed so as to prevent pelvic tilting. Adequate fixation can always be obtained in this way. The weight traction should be maintained for 3 months.

Well-leg traction

Roger Anderson's well-leg traction. Continuous traction in abduction can be maintained by Roger Anderson's well-leg traction (Anderson, 1932). The sound leg is held in extension by a full leg plaster. A below-knee plaster is applied to the affected leg incorporating a pin driven through the tibia above the ankle joint. The two legs are then fixed together by the apparatus (Fig. 134) which, when the screws are turned, pulls upon the affected leg, using the sound leg as counter-pull. The pelvis is tilted by the pull so that the affected hip is in full abduction. By this method the pelvis, legs and apparatus form a rigid parallelogram and the patient can be moved and allowed to sit up without danger of moving the fracture. Fixation is continued until the fracture unites, which usually takes 12 weeks.

Excellent reduction and immobilization can be obtained by this method but the prolonged fixation in extension of the sound knee may lead to permanent stiffness and pain in this joint. *Risk of stiff knee*

Immobilization on a Jones's frame is inadvisable in these cases as most of these fractures occur in elderly people who will not tolerate the firm fixation of a frame.

Internal fixation. These fractures cannot be fixed by the Smith-Petersen nail as the trochanteric region is so fragmented that the nail will not hold. A tri-flanged nail with an attached 4-screwed plate should be used (Fig. 135).



FIG. 135.—Tri-flanged nail with attached plate, used for the fixation of a basal fracture of the femoral neck with accompanying comminution of the lesser trochanter.

Technique

The fracture is reduced and the patient fixed upon an orthopaedic table. The trochanter and the upper-third of the shaft are exposed by a long incision. A guide wire is used and its position controlled by x-ray examination. When the guide is in accurate position, the nail is driven through the trochanter into the head. The plate is then fixed to the shaft by 4 screws which transfix the whole bone. No external splinting is necessary and free exercise is commenced immediately after the operation. Weight bearing should not be allowed until union is sound, usually after 3–4 months.

The operation is one of some magnitude and care should be taken in the selection of cases, since union can always be obtained by simple methods.

(iii) *Transtrochanteric fractures.*—The fracture line runs through the trochanter. Shortening and external rotation are present.

Reduction is obtained by traction and internal rotation. The position can be maintained either by continuous traction or by internal fixation, as in basal fractures with comminution. *Treatment*

(2) Shaft

(a) *Fractures of the upper third*

Displacement The upper fragment is abducted by the gluteal muscles and the lower fragment adducted by the adductors. If the fracture line runs below the lesser trochanter, the upper fragment is strongly flexed by the iliopsoas in addition to the abduction deformity.

Treatment.—These fractures are difficult to treat as the upper fragment is small and hard to control. Reduction is obtained by traction, full abduction of the leg and flexion at the hip joint. Re-displacement is constant unless continuous traction is maintained upon the leg. This is obtained either by a pin driven through the tuberosity of the tibia, or by adhesive tapes attached to the whole length of the leg, to which a weight is attached. The leg is supported in a Thomas's splint with a Pearson's attachment to hold the knee in flexion. The Thomas's splint is slung into full abduction and the pelvis fixed by fully abducting the opposite leg and fixing it to the side of the bed. The patient is propped up by a back-rest to increase the flexion of the hip joint, relax the psoas and bring the lower fragment into line with the flexed upper fragment. Such a position is comfortable for elderly patients and, provided the pelvis is fixed by abduction of both legs, affords adequate immobilization. Fixation is maintained until union is firm, usually in about 12 weeks, and knee exercises are practised after 6 weeks. After 12 weeks union is firm but an additional month of free exercise, without weight bearing is advisable to allow further consolidation of the fracture. When weight bearing is allowed, a caliper should *not* be used as this puts additional strain upon the fracture line when this is close to the upper end of the bone.

Fractures of the upper third of the femur with flexion of the upper fragment should not be treated in hip spica plasters or in a Jones's abduction frame as in both methods the hip joint is extended and the upward tilt of the upper fragment is uncontrolled. Morever, these methods of fixation are unwise in elderly patients. Roger Anderson's well-leg traction can be used but is open to the objections described on page 211.

(b) *Fractures of the middle third*

Displacement Spasm of the powerful thigh muscles causes considerable overlap of the fragments and, in addition, there is angulation, lateral displacement and rotation.

Treatment.—Overlap is corrected by powerful traction and the lateral and rotation deformities are corrected by direct manipulation. Re-displacement is prevented by continuous traction and firm splint fixation. Complete functional recovery will occur if the fragments are only partly in apposition, provided there is no shortening, angulation or rotation, and it is, therefore, unnecessary to adopt complicated and dangerous methods of reduction and fixation to obtain anatomical reduction.

Fixed traction and Thomas's bed knee-splint. Care must be taken to select a Thomas's splint with a ring which fits accurately against the tuberosity of the ischium. Extension is obtained by one-way stretch Elastoplast, 3 inches wide, to one end of which is stitched tape or lamp-wick. Metal gutter splints, the length of the thigh, are also required. The patient is anaesthetized and the shortening overcome by powerful manual traction. Whilst traction is

maintained by an assistant, the splint is passed over the leg and forced up against the tuberosity of the ischium. The extension strapping is applied to each side of the limb from just above the ankle to the upper third of the thigh, and is firmly fixed to the leg by a soft crêpe or flannel bandage. Strips of firm flannel bandage are placed across the bars of the Thomas's splint and a padded gutter splint, reaching from the thigh to below the calf, is laid upon them. The leg is then lowered on to the slings. The knee must be kept in slight flexion by a pad behind the joint. The traction tapes are next tied across the cross-bar, thus maintaining the traction against the counter-traction of the ring pressing upon the tuberosity of the ischium. Lateral displacement is then corrected by direct manipulation, and position maintained by two gutter splints applied to each side of the thigh and firmly bandaged in place. Pressure upon the ischium can be relieved by tying the splint to the foot of the bed and elevating the foot 12–18 inches. The traction tapes are tightened twice a day and the splint is constantly inspected. Foot exercises are practised throughout and quadriceps drill is practised after the third week. Union is usually sound in 12 weeks, after which the splint can be discarded and the patient allowed up. After discarding the splint, it is advisable to support the fracture, whilst weight bearing, by a Thomas's caliper for 6–8 weeks.

As soon as union is sound, knee exercises should be commenced. Recovery of knee flexion is often slow but, with persistent exercise, flexion up to 140° is usually obtained within 6 months.

Weight extension and balanced traction. The leg is supported with the knee flexed to about 30° upon a Thomas's splint with a Pearson's attachment. A Steinmann's pin is driven through the tuberosity of the tibia and a freely rotating stirrup attached to the pin. The splint is suspended from an overhead beam and a cord tied to the ring of the splint is passed over a pulley at the head of the bed and attached to a weight, thus pulling the ring upwards and backwards. A weight of about 20 pounds is fixed to the stirrup of the pin. When the shortening is corrected, lateral displacement is overcome by direct manipulation and pads and gutter splints are applied to the side of the thigh with bandages. *Great care must be taken not to distract the fragments.*

Care to avoid distraction

Control skiagrams are taken in 2–3 days and the weight is reduced so that there is neither distraction nor re-displacement of the fragments. After 6–8 weeks the pin is removed and replaced by strapping extension, this being maintained until union is firm, which usually takes a further 4–6 weeks. When union is firm, the splint is removed and weight bearing allowed with the support of a Thomas's caliper for 6–8 weeks. As soon as union is sound, knee exercises are practised constantly.

(c) *Fractures of the lower third*

Displacement

When the fracture line runs through the lower third of the femur, the pull of the gastrocnemius strongly flexes the small lower fragment.

(i) *Treatment.*—Reduction of the deformity is difficult and is sometimes complicated by soft tissue impacted between the fragments, the sharp lower end of the upper fragment having pierced the quadriceps. Two methods of manipulative reduction have been advocated.

Böhler's method (Böhler, 1935d). A Steinmann's pin is driven through the tuberosity of the tibia and a weight attached. The leg is supported on a

Braun's frame in such a position that the angle of the frame is behind the fracture and not behind the knee joint. The angle of the frame, acting as a fulcrum, allows the weight to lever the lower fragment forwards (Fig. 136).

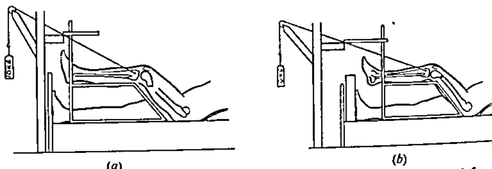


FIG. 136.—Böhler's method for fractures of lower third of femur: (*a*) with the Braun's frame behind the knee the posterior angulation is uncorrected; (*b*) with the Braun's frame behind the fracture the angulation is overcome.

Traction is maintained for 12 weeks. For the last 6 weeks extension tapes replace the tibial pin, which is removed.

Watson-Jones's method (Watson-Jones, 1943d). The patient is placed upon an orthopaedic table which permits vertical and horizontal traction. One pin is driven through the tibial tuberosity and a second pin through the lower fragment as close to the fracture as possible. The displacement is then reduced by

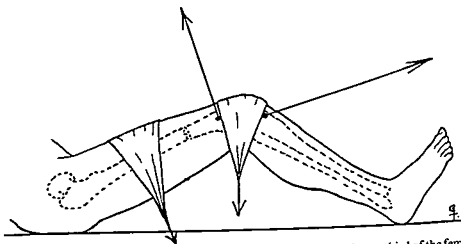


FIG. 137.—Watson-Jones's method of reduction of fractures of the lower third of the femur.

Longitudinal and vertical traction

longitudinal and vertical traction. Counter-traction to the vertical pull is obtained by two strips, one over the middle of the thigh and the other over the knee joint (Fig. 137). When reduction is complete, the leg is fixed in a hip spica plaster incorporating the two pins. After 4 weeks the plaster is changed and the pins are removed. Immobilization is continued until the fracture is united, which is usually in 12 weeks.

Open reduction. Both these methods of reduction frequently fail, due to interposition of soft tissue. In such cases the displacement must be reduced by open operation. The fracture is exposed by an external incision and the

fragments are levered into place and impacted. The limb is then immobilized in a plaster spica until union is sound. If the fracture is unstable the fragments are held by an onlay graft fixed with vitallium screws or by a vitallium plate.

(ii) *Subsequent knee stiffness.*—Stiffness of the knee joint commonly follows this fracture. Energetic exercises, perhaps with manipulation after 6–8 months of treatment, should be carried out.

(d) Fractures of the femur in children

Fractures of the femur in small children cannot be immobilized easily in a Thomas's splint. Immobilization is best obtained by fixation to a gallows (Fig. 138). Adhesive tapes are applied to both legs, which are then tied to the horizontal beam of the gallows, so that the buttocks are lifted clear of the bed, the child's body-weight thus providing the extension. This position is maintained until union is sound, which is usually in 6–8 weeks.



FIG. 138.—Fracture of the femur in a child. Immobilization by traction to an overhead gallows.

(3) Condyles

The shaft of the femur is occasionally driven down into the lower extremity, splitting the condyles.

Treatment

The displacement is reduced by powerful traction upon a Steinmann's pin through the tuberosity of the tibia, followed by manual compression of the condyles to reduce the lateral displacement. The leg is immobilized in a Thomas's splint with the knee flexed on a Pearson's attachment. Continuous traction is maintained by a weight slung from the tibial pin.

If reduction cannot be obtained in this manner, or if one condyle is separated and rotated, then open reduction should be performed and the fragments fixed by one or more long vitallium screws. *Open reduction*

4. DISLOCATION OF THE KNEE

Direct violence to the head of the tibia and powerful hyperextension or rotation strains may rupture the ligaments of the knee and dislocate the joint. *Aetiology*

(1) Displacement

The tibia may be displaced backwards, forwards or laterally on the femur. The dislocation is accompanied by rupture of the ligaments of the knee and by extensive tearing of the capsule.

(2) Treatment

Reduction Usually reduction is easily effected by traction upon the flexed knee with direct manipulation of the displaced bones.

Immobilization Reduction may be followed by prolonged immobilization—from 12 to 14 weeks in an unpadded plaster with the knee in slight flexion. Prolonged immobilization is necessary to allow the torn ligaments to heal as far as possible.

Quadriceps exercises During the period of immobilization, active quadriceps contraction should be practised regularly. Repair of the torn ligaments, particularly the cruciate ligaments, is usually unsatisfactory and the future stability of the knee will depend upon a powerful quadriceps. Persistent exercise must be carried out both during and after immobilization.

Interposition of the capsule Occasionally reduction by manipulation is incomplete, the inner or outer side of the joint remaining wider than normal as shown by x-ray examination. This may be due to interposition of the capsule between the tibia and the femur. *In such cases reduction cannot be completed until the capsule has* been hooked out of the joint by open operation. At the same time the torn lateral ligament should be sutured.

(3) Complications

(*a*) *Popliteal artery*

The popliteal artery is occasionally damaged in dislocation of the knee, and the interference with circulation may lead to gangrene and necessitate amputation.

(*b*) *External popliteal nerve*

The external popliteal nerve may be stretched or ruptured, particularly in medial dislocations. Exploration is advisable, but in at least 50 per cent of the cases the nerve is so damaged that repair is impossible and permanent foot-drop results.

5. FRACTURES OF THE PATELLA

Displacement The patella may be fractured either by direct violence or by sudden contraction of the quadriceps. In the former case the bone is fragmented but the quadriceps expansion is not ruptured, so that the fragments are not displaced (stellate fracture). In the latter case the bone is broken into two pieces, the quadriceps expansion is ruptured and the fragments are widely separated. Occasionally as a result of the combination of both types of violence, the patella is comminuted, the expansion is ruptured and the fragments are widely displaced.

Treatment

The object of treatment is to restore the extensor mechanism of the knee and to prevent progressive damage to the joint, from the friction of an irregular articular facet of the patella.

Stellate fractures without rupture of the aponeurosis present no problem. Immobilization in a full leg plaster for 6–8 weeks, followed by active exercise, is all that is necessary.

Transverse or comminuted fractures In transverse or comminuted fractures with separation of the fragments, open operation is necessary to restore the extensor mechanism and to provide a smooth surface against the femoral articular facet.

(a) Suture

The fracture is exposed by a U-shaped or transverse incision. The surfaces are cleared and the knee joint is emptied of blood clot. An encircling suture of strong catgut or silk is passed round both fragments and drawn tight so as to obtain an accurate reduction. The torn extensor aponeurosis is then sutured firmly, careful attention being paid to the lateral expansions which are often torn. The limb is immobilized in plaster for 8 weeks, and mobilizing exercises are then commenced. *Technique*

(b) Excision

Brooke (1937) maintains that the patella is unnecessary for full functional use of the knee and advocates excision of the fragments and repair of the aponeurosis. The fragments are excised through a U-shaped or transverse incision, and the aponeurosis is sutured with strong catgut mattress sutures or fascia. The aponeurosis is bunched and overlapped if necessary. The joint is immobilized for 3 weeks in a Thomas's splint, followed by active exercises. Recovery is complete in 3 months.

Excision of the patella is not recommended for all cases. When excision is performed, great care must be taken to suture the quadriceps firmly and tightly, otherwise there will be loss of the final few degrees of extension, and instability of the knee. Even with firm suture this occasionally happens. *Defects of suture*

Indications.—Excision should not be performed upon stellate fractures without displacement or upon transverse fractures in young people. The bone should be removed after comminuted fractures, when it is unlikely that the fragments can be accurately replaced, and in transverse fractures in elderly patients, in whom suture is likely to be followed by rapid degenerative arthritis.

When a small fragment is avulsed, from either the upper or the lower pole of the patella, the fragment should be removed even in young people. *Avulsion of a small fragment*

6. FRACTURES OF THE TIBIA

(1) Spine

Fracture of the tibial spine is caused by a blow upon the front of the flexed knee, sudden tension upon the anterior cruciate ligament pulling off a fragment of the tibial spine. If there is additional rotational strain, rupture of the internal lateral ligament also occurs. The injury must be suspected if, after a severe blow or twist, there is sudden swelling of the joint, indicating a haemarthrosis. *Diagnosis*

Treatment

If there is displacement, the fragment must be replaced by open operation, otherwise persistent instability of the knee may result and the last few degrees of extension may be lost.

The joint is opened by a medial incision and the fragment exposed. Two drill holes are made from the region of the tubercle of the tibia up into the cavity from which the fragment has been torn. Accurate alignment of the drill is assured by the use of a drill guide. A stainless-steel wire suture is passed along one drill hole over the fragment and out at the other drill hole, and the suture tied over the outer cortex of the tibia. The knee is immobilized for 8 weeks in plaster. Quadriceps exercises are practised throughout. *Open operation*

(2) Tibial condyles

(a) *External condyle*

Aetiology

Forcible abduction of the knee may rupture the internal lateral ligament and fracture the external condyle of the tibia by the impact of the external condyle of the femur.

Displacement

With moderately severe violence the condyle is separated as one piece and driven into the head of the tibia. With very severe violence the condyle is comminuted, usually one large fragment being widely separated and several

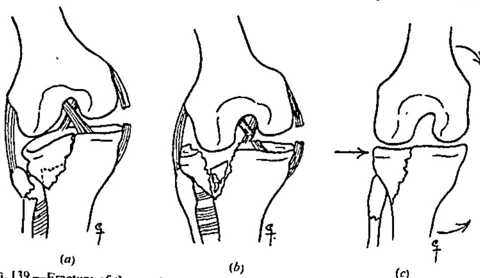


FIG. 139.—Fracture of the condyle of the tibia. (*a*) Single large fragment; (*b*) comminuted fracture; (*c*) reduction by powerful adduction at the knee and direct pressure over the fragment.

small fragments driven deep into the head of the tibia (Fig. 139). In such cases the cruciate ligaments are also ruptured.

(i) *Treatment when a single large fragment is separated.*—When the fracture separates one large fragment, manipulative reduction usually succeeds in restoring the upper articular facet of the tibia to normal shape.

Manipulative reduction

When gross swelling of the knee joint is present, reduction should be deferred for 6–8 days, the blood being aspirated from the joint and the leg immobilized upon a Thomas's splint. The patient is then anaesthetized and powerful traction in extension applied to the leg. The knee is then forced into adduction to correct the valgus deformity and the separated condyle pressed into place with the hands or with a well-padded Böhler's clamp. A plaster is then applied from the groin to the toes.

The fracture unites rapidly but consolidation is slow. After 4–6 weeks redisplacement will not occur provided the patient does not bear weight on the leg. The cast can, therefore, be removed and free non-weight-bearing exercises encouraged. Weight bearing should not be allowed for 12–14 weeks after the fracture.

(ii) *Treatment of comminuted fractures.*—Comminuted fractures of the condyle have a much more unfavourable prognosis. Accurate reduction is difficult or impossible because replacement of the large fragments is prevented by the impaction of the smaller fragments in the tibial head. Moreover, the

articular surface is so shattered that it cannot be restored to normal shape. Attempts should be made to restore the position as far as possible by manipulation, as for the separated condyle. Kindersley's method will often produce improvement in position. The upper end of the tibia is surrounded by an Esmarch's bandage or by firm padding and the displaced condyle hammered into place by means of a mallet. The padding or bandage is then removed and the limb immobilized in plaster. If reduction is not obtained by this method, open reduction may be attempted.

Open reduction

The joint is opened on the outer side, the external cartilage, which is usually caught between the fragments, is removed and the depressed fragments are elevated and fitted together as far as possible. Internal fixation is unnecessary. The leg is immobilized in a plaster from the groin to the toes. In all cases of comminuted fracture, immobilization should continue for 4–6 weeks and be followed by active knee exercises. Weight bearing should not be permitted for 3 months.

(*b*) *Internal condyle*

Forcible adduction strains may rupture the external lateral ligament and fracture the internal condyle of the tibia. Such cases are rare and may be complicated by dislocation of the knee and paralysis of the external popliteal nerve. Treatment is similar to that for fractures of the external condyle.

(*c*) *Both condyles*

Severe violence along the line of the tibia may drive the shaft deep into the upper extremity, so splitting and separating the condyles.

Treatment.—The shaft is disimpacted from the condyles by powerful traction from a pin through the os calcis and a traction frame. The separated condyles are then pressed together by the hands or a clamp and the leg is immobilized in plaster. Re-displacement is prevented by continuous traction by a weight slung from the pin. Traction is maintained for 6 weeks and immobilization continued for a further 6 weeks.

Exercises

Rupture of the ligaments associated with fractures of the condyles of the tibia will result in persistent instability of the knee unless good muscle control is developed. Quadriceps exercises should be practised constantly, both during and after immobilization. With powerful quadriceps action, surprising functional recovery often occurs in most severe cases.

Arthrodesis

The prognosis, however, especially in comminuted fractures, should be guarded. Good reduction is often impossible and, even if obtained, is frequently followed by a painful knee with only a few degrees of movement. In such cases, after trial, arthrodesis should be performed.

7. FRACTURES OF THE TIBIA AND FIBULA

(1) Shafts

Transverse, oblique and comminuted fractures of the tibia and fibula are common. The tibia is subcutaneous throughout its extent so that a high percentage of the fractures are compound. The fragments are often widely displaced, there being angulation, rotation and, especially in the spiral fractures, overriding. Shortening, angulation and rotation must be accurately reduced. Lateral displacement is not so important because full functional recovery occurs with no more than one-quarter apposition.

(a) *Fractures without shortening*

Treatment.—When there is no shortening, all that is necessary is to correct the angulation and rotation by manipulation, and to immobilize the leg with the knee in 10°–15° of flexion in a close-fitting plaster extending from the groin to the toes. The plaster is removed when union is sound, usually in 12–14 weeks.

(b) *Fractures with shortening*

Manual reduction

(i) *Treatment.*—Overriding of the fragments must be overcome by traction. In some transverse fractures it is possible to reduce the overriding and to impact

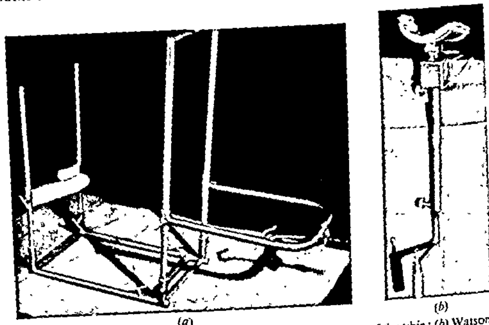


FIG. 140.—(a) Bohler's traction frame for reduction of fractures of the tibia; (b) Watson-Jones's traction frame.

the fragments by manual traction and manipulation with the knee in flexion over the end of a table. The fracture is then stable. A full leg cast is applied and retained until union is sound. Most fractures, however, require more powerful traction for reduction.

Reduction by skeletal traction

A Steinmann's pin is driven through the tuberosity of the calcaneum or through the tibia 1 inch above the ankle joint. A stirrup is attached to the pin and the leg placed on a Böhler's or a Watson-Jones's traction frame (Fig. 140). Traction is applied to the stirrup by the screw of the frame until the overriding is reduced. Remaining rotation and angulation are corrected by manipulation, and the leg is immobilized in plaster which extends to the knee. When the plaster is set, the traction frame is removed and the plaster continued to the groin with the knee held in 10°–15° of flexion. The reduction is controlled by x-ray examination.

Continuous traction

(ii) *Prevention of re-displacement.*—After successful reduction, re-displacement sometimes occurs, especially if there is marked swelling or if the fracture is oblique or spiral. If the reduction is unstable, re-displacement will occur, unless continuous traction is applied for 4–6 weeks. The leg, immobilized in plaster, is placed upon a Braun's frame and a weight slung from the traction

pin (Fig. 141). *The weight must not be heavy enough to distract the fragments or union will be delayed.* After 4–6 weeks, union is sufficiently firm to prevent re-displacement. The plaster is removed, the pin extracted and a new plaster applied, which is retained until union is sound, usually in 12–14 weeks.

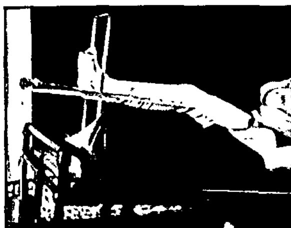
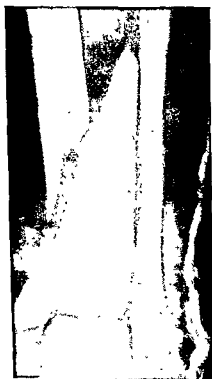


Fig. 141.—Fracture of the tibia reduced by traction and immobilized in plaster. The position is maintained by *continuous pull exerted by means of a weight attached* to a pin driven through the os calcis.

Internal fixation

Re-displacement in spiral and oblique fractures of the tibia and fibula can be prevented by internal fixation as an alternative to continuous traction. The fracture is exposed by a curved incision over the subcutaneous border of the tibia. The fragments are manipulated into place with bone-holding forceps and fixed with a bone clamp. One or two screws are then driven across the fracture, which is thus



(*a*)



(*b*)

Fig. 142.—(*a*) Spiral fracture of the tibia; (*b*) fracture fixed by a vitallium screw driven across the fragments. The leg is then immobilized in plaster.

firmly held (Fig. 142). The leg is then immobilized in a full plaster, extending from the groin to the metatarsal heads with the knee in slight flexion. The plaster and stitches are removed in 10–14 days and a new plaster is applied, which is retained until the fracture is united.

Internal fixation assures close apposition of the fragments and avoids the risk of distraction with consequent delayed union. The operation is, however, not devoid of difficulty and should be performed only in suitable surroundings and by surgeons of experience.

(2) Fractures involving the ankle joint

Fractures involving the ankle joint are extremely common and range from simple cracks of the malleoli to severe fracture-dislocations of the joint. In all

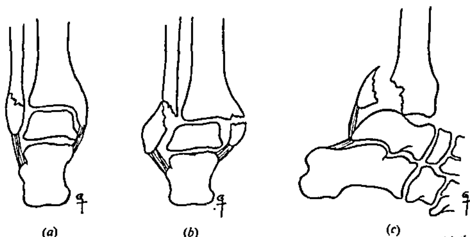


FIG. 143.—Abduction fracture of the ankle: (*a*) first degree; (*b*) second degree; (*c*) third degree.

cases great care must be taken to obtain an accurate reduction. The smallest displacement of the articular surfaces of the joint will, as a result of weight bearing, inevitably lead to degenerative arthritis with persistent pain and grave disability.

Ankle fractures can be classified into abduction, adduction and compression fractures.

(*a*) *Abduction fractures*

Abduction fractures result from forcible abduction of the foot upon the leg, usually associated with rotational strain. They are subdivided into three groups (Fig. 143):

(i) *First degree.*—There is a fracture of the external malleolus running from below upwards and outwards. Frequently there is no displacement but, if the internal lateral ligament is damaged, indicated by tenderness below the internal malleolus, some widening of the ankle mortise may occur.

Strapping

When there is no displacement, it is sufficient to strap the ankle firmly with adhesive strapping and allow weight bearing in a firm shoe. Great care must be taken, however, to detect any outward displacement of the talus. When this is present, the displacement must be accurately reduced by firm pressure with the hands, and the leg and foot immobilized in a below-knee plaster for 6–8 weeks.

Failure to recognize and reduce lateral displacement results in an unstable painful ankle. For this reason many surgeons consider it advisable to immobilize all fractures of the external malleolus in plaster.

(ii) *Second degree.*—The fracture of the external malleolus is associated with fracture of the internal malleolus or rupture of the internal lateral ligament of the ankle. The talus is displaced outwards, carrying the malleoli with it. In pure abduction injuries the fracture of the fibula may lie above the lower tibio-fibular joint. In such cases there is often rupture of the lower tibio-fibular ligament and separation of the two bones (Fig. 144).

Risk of arthritis

The displacement must be accurately reduced so as to restore the normal ankle mortise. Failure to reduce and maintain accurate position will lead to degenerative arthritis and persistent pain. Manual reduction and fixation in a close-fitting non-padded plaster is usually sufficient but reduction must be controlled by x-ray examination and further examinations should be made at regular intervals during immobilization.

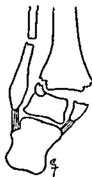


FIG. 144.—Second-degree abduction fracture with separation of the lower tibio-fibular joint.

With the patient anaesthetized and the leg hanging over the end of the table, the lateral displacement is reduced by strong inward pressure. The leg and foot are then immobilized in a close-fitting plaster, extending from the toes to the knee. Whilst the plaster is setting, inward pressure is maintained upon the lower fragment. If there is much swelling, the plaster must be changed as soon as this subsides. Failure to change the cast will result in loss of firm immobilization and in re-displacement. After change of plaster, weight bearing is allowed upon a boot or rubber heel incorporated in the plaster. Fixation is maintained for 8–10 weeks. After removal of the plaster, the ankle is supported for a further 4–6 weeks by Elastoplast or Unna's paste.

When fracture of the malleoli is associated with separation of the lower tibio-fibular joint, internal fixation must be considered. Accurate manipulative reduction, followed by immobilization for not less than 3 months, usually results in stability of the ankle, but the period of immobilization is shortened and a satisfactory result more certain if internal fixation is employed.

Open reduction

Technique

Through a small vertical incision over the lower end of the fibula, a long screw is driven through the fibula half an inch above its lower extremity, through the lower tibio-fibular joint and across the tibia, so as to engage the opposite cortex. As the screw is driven home, the foot is held at a right angle. After fixation the leg is immobilized in a plaster for 6–8 weeks, weight bearing being allowed after 4 weeks.

(iii) *Third degree.*—In addition to fracture of both malleoli, a fragment is detached from the posterior edge of the articular facet of the tibia. The talus is dislocated backwards.

Treatment

Reduction is easily effected but re-displacement is common, especially if the detached tibial fragment is large. When this fragment involves more than one-third of the lower articular facet, it is difficult to prevent re-displacement, unless continuous traction is maintained upon the foot.

With a small tibial fragment reduction is simple, by direct manipulation with

the leg hanging over the edge of the table. Fixation and after-treatment are as for second-degree fractures. When the tibial fragment is large, re-displacement constantly occurs. In such cases a Steinmann's pin is driven through the calcaneum, the fracture-dislocation reduced by traction on a frame and direct manipulation, and a plaster applied incorporating the pin. The leg is then supported on a Braun's frame and a weight suspended from the pin. Traction is maintained for 3–4 weeks, after which the pin is removed and the plaster replaced. Weight bearing is not allowed for 8–10 weeks and the plaster is removed after 12–14 weeks. Internal fixation by means of a screw may be used as an alternative to continuous traction. The tibial fragment is exposed by a straight incision lateral to the tendo Achillis. The fragment is manipulated

Continuous traction

Internal fixation

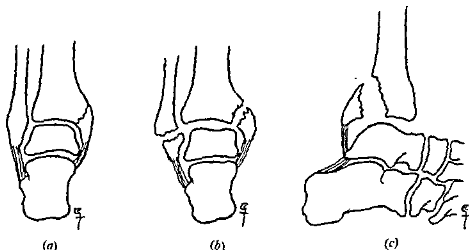


FIG. 145.—Adduction fracture of the ankle: (*a*) first degree; (*b*) second degree; (*c*) third degree.

into position, care being taken to preserve any soft-tissue attachments, and is fixed by means of a long vitallium screw.

(*b*) *Adduction fractures*

Forcible adduction of the ankle results in fracture of the malleoli. Three degrees of adduction fracture occur (Fig. 145):

(i) *First degree.*—The internal malleolus is fractured. The fracture line runs below upwards and inwards. There is no displacement as the external lateral ligament and the external malleolus are undamaged.

Reduction unnecessary

Reduction is unnecessary. The ankle should be immobilized for 6–8 weeks in a close-fitting plaster extending from the knee to the metatarsal heads.

(ii) *Second degree.*—In this case there is fracture of the internal malleolus associated with fracture of the external malleolus and medial subluxation of the talus. The fracture line runs horizontally through the external malleolus.

Reduction of subluxation

The subluxation must be accurately reduced by firm outward pressure upon the internal malleolus and talus with the leg hanging over the end of the table. Reduction is controlled by x-ray examination. The ankle is then immobilized in a plaster for 8–10 weeks until union is sound.

Internal malleolus

Occasionally a flap of periosteum is caught between the internal malleolus and the tibia and accurate manipulative reduction is impossible. In such cases

the fracture must be exposed by a short longitudinal incision, the interposed periosteum pulled away and the fracture reduced. The internal malleolus is then fixed in position by a long screw or a bone graft. The leg is fixed in plaster until union is sound. *Open reduction*

(iii) *Third degree.*—Fracture of both malleoli is associated with a fracture of the posterior part of the lower facet of the tibia and there is medial and backward dislocation of the talus.

Such fractures are treated in a similar manner to third-degree abduction fracture-dislocations. *Treatment*

(c) *Compression fractures* (Fig. 146)

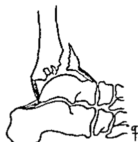


FIG. 146.—Compression fracture of the ankle.

A direct fall upon the foot may cause forward dislocation of the talus with separation of a large segment of the anterior part of the lower articular facet of the tibia. There is frequently comminution of the lower end of the tibia.

Treatment.—Reduction of the dislocation is easily effected but, unless the fragment is accurately replaced, re-dislocation always occurs. Manipulative reduction of the displaced fragment is usually unsatisfactory and open reduction with internal fixation is necessary. This should be done only if a single large fragment is separated as, in comminuted fractures, accurate replacement of all the fragments is usually impossible.

Open reduction and internal fixation. The fracture is exposed through a long anterior incision, the extensor tendons being drawn aside. The detached fragment is levered into place and fixed with a long vitallium screw. The ankle is then fixed in a below-knee cast for 8–12 weeks.

Manipulative reduction. In comminuted fractures it may be possible to obtain a reasonably satisfactory position and stability by direct manipulation with the ankle in plantar flexion. A below-knee plaster is then applied with the foot in plantar flexion and fixation continued for 12 weeks.

Arthrodesis. If a reasonably satisfactory position is obtained, a useful range of painless ankle movement results. When manipulation fails to obtain reduction —a common result—then degenerative arthritis is certain to occur after weight bearing. In such cases it is best to perform arthrodesis of the ankle at once.

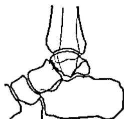


FIG. 147.—Fracture of the neck of the astragalus. A typical displacement is shown.

8. FRACTURES OF THE TALUS

Fractures of the neck of the talus are caused by forcible dorsiflexion of the foot. The fracture may be associated with dislocation of the posterior talocalcanean joint. In such cases the body of the talus is in the equinus position with the head and neck displaced upwards, there being an angle open upwards at the fracture line (Fig. 147). Very severe violence may result in total dislocation of the body of the talus postero-medially with associated fracture of the medial malleolus.

(1) Fractures without displacement

Treatment

Fractures without displacement should be immobilized in a leg plaster for 12 weeks. Union occurs satisfactorily and an excellent result is usually obtained.

(2) Fractures with displacement and posterior talo-calcanean dislocation

These fractures require reduction (Watson-Jones, 1943e). The head and neck of the bone must be brought into the equinus position so as to be in line with the body. With the patient anaesthetized and the knee flexed, the foot is placed in *full plantar flexion and eversion* and immobilized in this position in a leg plaster. Reduction is confirmed by x-ray examination. Immobilization in this position is maintained for 8 weeks, after which time the cast is changed and the foot brought to right angles for a further month. In many of these cases there is subsequent degenerative arthritis from avascular necrosis of the body of the talus.

Plantar flexion and eversion

(3) Fracture with total dislocation of the body of the talus

The displaced body of the talus lies immediately under the skin on the medial side of the ankle. The skin is stretched so tightly that sloughing rapidly occurs unless reduction is carried out immediately.

(i) *Manipulative reduction.*—The foot is forced into full dorsiflexion and inversion and the displaced body replaced by direct pressure. If this manoeuvre is successful, the foot is then immobilized in full plantar flexion and eversion for 8 weeks, after which time immobilization at right angles is effected for a further 4 weeks.

(ii) *Open reduction.*—When manipulative reduction fails, open operation should be undertaken at once. The body of the bone is exposed through a medial incision and levered back into place. The foot is then immobilized as after manipulative reduction.

Risk of avascular necrosis

Avascular necrosis of the body of the talus frequently follows this injury. Degenerative arthritis of the ankle and subtaloid joints occurs, and is best treated by tibio-calcanean arthrodesis or by removal of the talus.

9. SUBTALOID DISLOCATION

Forcible inversion or eversion of the foot may result in subtaloid dislocation without fracture (Fig. 148). *The talus remains in the ankle mortise* and the rest of the foot is displaced outwards or inwards. Inward dislocation is far more common.

(1) Inward dislocation

Treatment

Reduction is reasonably easy by traction upon the foot with the knee fully flexed. After reduction the foot is immobilized at right angles for 8 weeks. Weight bearing is allowed after 4 weeks.

(2) Outward dislocation

Manipulative reduction is very often prevented by the flexor tendons catching round the neck of the talus. When manipulative reduction fails, the neck of the talus should be freed through a short incision on the inner side. Reduction is then easy.

Open reduction

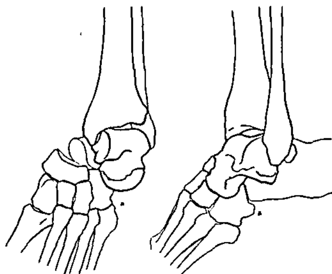


FIG. 148.—Subtaloid dislocation.

10. FRACTURES OF THE CALCANEUM

Fractures of the calcaneum are caused by direct falls upon the heel. The fractures can be classified into three main groups (Fig. 149):

(1) Fractures without joint injury.

(2) Comminuted fractures with minimal joint injury.

(3) Comminuted fractures with severe joint injury.

Of these fractures the third group is the most common.

The three varieties can be distinguished only by accurate radiography as the heel is so very swollen that accurate palpation is impossible. X-ray

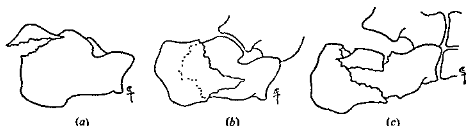


FIG. 149.—Fractures of the calcaneum: (*a*) tuberosity fracture with displacement; (*b*) comminuted fracture with minimal joint involvement; (*c*) comminuted fracture with severe joint involvement.

examination of the heel must be carried out in both the lateral and antero-posterior planes.

(1) Fractures without joint involvement

Treatment

In crack fractures of the calcaneum without displacement the fragments are impacted and, if weight bearing is forbidden, displacement will not occur and union may be expected in 12 weeks. The foot should be exercised throughout and supported by a firm pressure bandage for the first 4 weeks.

Separation of the tuberosity

Separation of the tuberosity sometimes occurs. Manipulative reduction is usually not possible and open reduction should be performed.

Open reduction.—The fragment is exposed through a curved lateral incision, replaced and fixed by a stitch or screw. The foot is then immobilized in plantar flexion for 8 weeks and weight bearing prohibited for 3 months.

(2) Comminuted fractures with minimal joint injury

The posterior part of the calcaneum is broadened and displaced upwards in this fracture. The outer half of the posterior subtaloid joint is displaced upwards.

Treatment

In such cases reduction by Böhler's method offers a reasonable chance of a successful result.

Böhler's method.—Reduction is deferred for 5–6 days until the swelling subsides. With the ankle held at a right angle a Steinmann's pin is driven through the tuberosity of the calcaneum. A stirrup is attached and powerful traction applied in the long axis of the leg by means of Böhler's screw-traction frame. A second pin is driven through the lower end of the tibia 2–3 inches above the ankle joint. A stirrup is attached to the second pin and tied to a bar vertically above. The long-axis traction is then released and the screw lowered. Traction is then applied by the screw downwards and backwards in the axis of the calcaneum. Broadening of the posterior part of the bone is then corrected by the Böhler's clamp. The two pads of the clamp are placed on the sides of the bone and the screw is turned until the width of the calcaneum is reduced to the width of the normal bone on the uninjured side. Reduction should be controlled by x-ray examination. The leg is then immobilized in a cast extending from the metatarsal heads to the knee. The calcanean pin is incorporated in the plaster. The leg is supported on a Braun's frame and a weight (12 pounds) attached to the pin. Continuous traction is thus maintained for 3 months. The cast should be replaced after 6 weeks. After this time the swelling has disappeared and the cast has become loose. After 3 months a walking cast is applied for 4–6 weeks, followed by elastic strapping for a further 6–8 weeks.

(3) Comminuted fractures with complete disorganization of the subtaloid joint

Excessive violence may completely disorganize the subtaloid joint and fragment the talus. Sections of the bone are deprived of their blood supply and undergo avascular necrosis. Such necrosis may be followed by severe subtaloid arthritis and permanent disability. Attempts at reduction are not successful. Three methods of treatment are available.

Avascular necrosis

(a) Conservative treatment

No attempt at reduction is made. The foot is supported by a firm bandage for 6 weeks and weight bearing prohibited for 4 months. Foot and ankle exercises are practised throughout. After 4 months, weight bearing is allowed. In many cases such treatment results in fair function, though walking on rough ground is always painful.

(b) Subtaloid arthrodesis

When the subtaloid joint is disorganized immediate subtaloid arthrodesis

can be performed. The joint is opened through a horizontal external incision and the cartilage removed from the undersurface of the talus and the disorganized calcaneum. Following operation the foot is immobilized in plaster for 12 weeks. Weight bearing is allowed after 8 weeks.

Subtaloid arthrodesis is also indicated when, after conservative treatment, the foot remains painful from subtaloid arthritis.

(c) *Excision of the calcaneum*

Recently, total removal of the calcaneum through a posterior or lateral incision has been advocated. Through a vertical incision splitting the heel the whole bone is removed and the tendo Achillis sutured to the plantar fascia. As yet, an insufficient number of cases have been reported to assess the value of this procedure.

(d) *After-treatment*

After fractures of the calcaneum it is advisable to fit a soft Sorbo rubber insole into the shoe for 6–8 months. The cushioning of the heel greatly adds to the comfort of walking.

11. FRACTURE OF THE NAVICULAR

Small chip fractures of the navicular are common. They require only a short period of immobilization in a plaster.

The tuberosity of the navicular is sometimes separated by the pull of the tibialis posterior. In such cases the leg is immobilized in a walking plaster for 8 weeks.

Crush injuries to the foot may comminute the navicular, narrowing the bone and separating a large dorsal fragment, which is forced upwards.

Mid-tarsal arthritis

Reduction is possible by skeletal traction but the results are unsatisfactory as the fragments re-displace. Degenerative arthritis of the mid-tarsal joint is the constant result.

Arthrodesis.—Immediate mid-tarsal arthrodesis by bone graft from the talus to the cuneiform is the best treatment. After operation the foot is immobilized in plaster until union is sound, which usually is in 12 weeks.

12. MID-TARSAL DISLOCATION

The mid-tarsal (talo-navicular calcaneo-cuboid) joint may be dislocated by adduction or abduction strains. The dislocation is usually associated with fracture of the navicular.

Treatment

Reduction is easily effected but is usually unstable because of the associated fracture. Early arthrodesis of the mid-tarsal joints is the best form of treatment.

13. FRACTURES OF THE METATARSALS

Crush injuries of the foot caused by falling weights or run-over injuries produce fractures of the metatarsals.

(1) First metatarsal

The commonest fracture of the first metatarsal is a comminuted fracture without displacement.

Treatment

The fracture should be treated by immobilization in a close-fitting below-knee plaster for 6 weeks. Weight bearing is allowed and toe exercises are practised throughout the treatment period.

(2) Outer metatarsals

The second, third and fourth metatarsals are most frequently fractured through their necks. The heads of the bone are displaced into the sole and, if union occurs in this position, pain on walking is the result. The fractures must be reduced by powerful traction upon the toes after the swelling has subsided. When satisfactory reduction is obtained a close-fitting below-knee plaster is applied and retained for 4–6 weeks. Weight bearing is allowed.

When manipulative reduction fails, operative reduction should be carried out.

Open reduction

The fracture is exposed through a dorsal incision and the head levered into place. After operation a below-knee cast is applied as above.

Crush injuries of the forefoot often lead to severe swelling of the foot and the circulation of the toes may be endangered. It is advisable to defer reduction and fixation in such cases for 4–7 days until the swelling has subsided. The patient should be kept in bed with the foot elevated and supported by a crêpe bandage.

(3) March fracture

The shaft or neck of the second, third or fourth metatarsal may fracture during ordinary walking. This fracture occurs frequently in soldiers after long route-marches. Sudden pain occurs, followed by swelling of the foot and, on examination, there is marked tenderness over the affected bone. The condition is revealed by skiagrams which show a fine crack-fracture of the bone. If the case is seen after 1 or 2 weeks, callus formation may obscure the fracture line and lead to a diagnosis of periostitis.

March fracture should be treated as any other fracture by immobilization until union is sound. A below-knee cast is applied for 4–5 weeks, weight bearing being allowed in the plaster.

Below-knee cast

An alternative to plaster is to strap the foot firmly with Elastoplast and allow gentle weight bearing in a firm boot fitted with an inside support.

14. FRACTURES OF THE TOES

Fractures of the phalanges of the great toe are common and result from dropping weights upon the toe. The phalanges are usually comminuted and displacement is uncommon.

Treatment

Immobilization by slips of collodion gauze, and weight bearing in a boot fitted with a metatarsal bar for 4–6 weeks, results in recovery.

Fractures of the proximal phalanx which involve the metatarso-phalangeal joint, occasionally result in stiffness of that joint or hallux rigidus. Walking is painful in such cases. When the condition is not relieved by a metatarsal bar on the shoe, two-thirds of the proximal phalanx should be removed through a dorso-medial incision (Keller's operation).

Fractures of the phalanges of the small toes may be treated in a similar way. If several toes are fractured, however, it is advisable to immobilize for 4–5 weeks in a below-knee cast extending to the tip of the toes.

Occasionally in fractures of the proximal phalanx the proximal fragment remains flexed and forms a painful prominence under the toe. In such cases the whole fragment should be excised.

15. LATE TREATMENT OF LEG AND FOOT INJURIES

Removal of the plaster in leg, ankle and foot fractures is frequently followed by swelling of the leg and pain in the foot. The swelling is due to oedema from vascular stasis and is best controlled by active exercises and by a firm supporting bandage from the metatarsal heads to the knee. A crêpe bandage gives effective support but easily displaces. Unna's paste applied on successive layers of gauze bandage gives the best support. The bandage should be retained for 6–8 weeks. *Oedema due vascular stasis*

Aching pain in the foot following leg and foot fractures is usually due to *foot strain. A Thomas's heel or arch support should be fitted for 3–6 months* following the removal of the cast. If there is marked eversion of the foot and pain is not relieved by supports, then an outside iron with an inside T-strap should be worn for 2–3 months. *Foot strain*

REFERENCES

Anderson, R. (1932). *Surg. Gynec. Obstet.*, **54**, 207.
Bankart, A. S. B. (1938a). *Brit. J. Surg.*, **26**, 23.
— (1938b). *Ibid.*, **26**, 320.
Böhler, L. (1935a). *The Treatment of Fractures*, 4th ed., p. 180. Transl. by E. W. H. Groves. Bristol; Wright.
— (1935b). *Ibid.*, p. 211.
— (1935c). *Ibid.*, p. 212.
— (1935d). *Ibid.*, p. 340.
Brooke, R. (1937). *Brit. J. Surg.*, **24**, 733.
Burns, B. H., and Young, R. H. (1944). *Lancet*, **1**, 723.
Eastwood, W. J. (1937). *J. Bone Jt Surg.*, **19**, 364.
Jahss, S. A. (1938). *J. Bone Jt Surg.*, **20**, 178.
Jones, R. (1904). *Clin. J.*, **25**, 17.
— (1932). *Brit. med. J.*, **1**, 739.
McMurray, T. P. (1936). *J. Bone Jt Surg.*, **18**, 319.
Mumford, E. B. (1941). *J. Bone Jt Surg.*, **23**, 799.
Naylor, A. (1942). *Brit. J. Surg.*, **29**, 323.
Nicola, T. (1934). *J. Bone Jt Surg.*, **16**, 663.
Patrick, J. (1946). *J. Bone Jt Surg.*, **28**, 737.
Roberts, N. W. (1934). *Lancet*, **2**, 78.
Speed, J. S., and Macey, H. B. (1933). *J. Bone Jt Surg.*, **15**, 903.
Watson-Jones, R. W. (1929). *Proc. R. Soc. Med.*, **22**, 1071.
— (1943a). *Fractures and Joint Injuries*, 3rd ed., Vol. II, p. 482. Edinburgh; Livingstone.
— (1943b). *Ibid.*, p. 499.
— (1943c). *Ibid.*, p. 636.
— (1943d). *Ibid.*, p. 690.
— (1943e). *Ibid.*, p. 832.
Wilson, P. D. (1936). *J. Bone Jt Surg.*, **18**, 312.

[References to other titles are given under Fractures, Dislocations, Fracture-dislocations and Allied Injuries in the Index Volume. The subject of Dislocations, Fractures, Fracture-dislocations, and Associated Injuries is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 4, p. 113.]

FROST-BITE

By NORMAN C. LAKE, D.Sc., M.D., M.S., F.R.C.S.
Senior Surgeon and Director Surgical Division, Charing Cross Hospital; Senior Surgeon, Bolingbroke Hospital, London

1. INTRODUCTION

160.] The term frost-bite is used rather loosely in Medicine to indicate the local effects of cold upon limited portions of the body, but does not normally include those general effects associated with what is often appropriately designated "exposure". Trench-foot, true frost-bite, immersion-foot, chilling, shelter-foot, are terms used to describe conditions aetiologically but not of necessity pathologically separate.

Human interest in the effects of cold undoubtedly extends back to prehistoric times, for the ice ages must have given mankind plenty of personal experience of frost-bite. Modern observations started when Napoleon's surgeon Larrey (1812) wrote his account of the disastrous retreat from Moscow. The official records of the Crimean War and of World War I (in the latter 84,671 cases were recorded in the British army alone) show how devastating the effects of cold can be in military campaigns. The peaks of interest have always been associated with wars owing to the numbers involved and to the extreme difficulties of providing adequate protection under all the exigencies of warfare. Thus in World War II there were large numbers of cases in the Russian and German armies on the Eastern front, but other armies escaped except for comparatively small numbers of exposed airmen and shipwrecked men.

2. PATHOLOGY

The pathology of the condition demands some attention, for if treatment is to be more than empirical it must be founded upon accurate pathology. The earlier theories attributing the condition to various causes, osmosis, infection and so on, have all been abandoned in favour of cold as the only essential aetiological factor. It is not, however, as yet certain whether the pathological processes in the various manifestations are exactly the same, and so the word cryopathies has been introduced to cover all the conditions arising from exposure of parts of the body to cold.

Cryopathies

For long it has been known that tissues stored at low temperatures could be successfully transplanted in the body, and furthermore that someforms of life, both cold-blooded and warm-blooded, could survive exposure to severe cold, to the point of apparent extinction of life, with little harm. It seems clear herefore that the well-known disastrous effects of trench-foot and frost-bite

are not to be explained completely by a facile reference to the direct effect of cold.

It was shown by Lake (1917) that tissues of warm-blooded animals actively growing *in vitro* would survive, without apparent harm or deterioration, exposures down to minus 5° C. for considerable periods, that is several weeks, and would regain their full activity and growth when again raised to body temperature. If, however, the temperature fell below about minus 5° C. the tissues were rapidly and permanently destroyed and all life ceased. This led to the suggestion that there was a critical temperature in the region of minus 5° C. above which cellular life could be maintained for long periods, but below which the structure of active cells was destroyed. These findings were confirmed in several ways, including human tissues both intact and excised. There was indeed a period of survival which could be correlated to the temperature as shown in the graph (Fig. 150).

Critical temperature

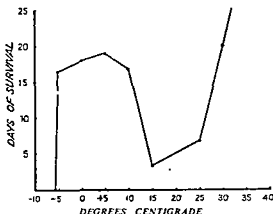


FIG. 150.—Curve showing survival period of tissues at various temperatures, as tested by subsequent ability to grow *in vitro*. The curves varied a little for different tissues, but all had the same characteristics. The short survival period between 30° C. and 10° C. is due to the fact that in this range anabolism ceases, but katabolism continues, whereas below 10° C. katabolism also ceases and the tissue passes into a state of suspended animation (Lake, 1917).

Before such observations can be applied to the pathology of the cryopathies it is essential to bear certain points in mind. These experiments relate to the succulent living and growing cells of warm-blooded animals, but in the tissues as we find them in the body such cells form but a percentage of the total mass. The rest of the tissue is composed of material which is for all practical purposes non-living, for example, fibrous and elastic structures and the main mass of solid bone.

Of course, such materials are controlled by neighbouring living cells but they are not in the truest sense themselves actively alive. They will not, therefore, respond to cold in the same way as active cells and may obviously not be affected by exposures beyond the critical point.

In the foot, for instance, it is probable that over 90 per cent of its mass is composed of such tissues which are only on the border-line of life.

This fact probably accounts for the discrepancy which occasionally appears in the interpretation which different experimenters apply to their observations.

Varying interpretations

A second point of importance to note is that protoplasm, that is cytoplasm, always displays the phenomenon of super-cooling (Lake, 1918, confirmed by Lewis and Love, 1926), so that much lower temperatures than would be expected theoretically are necessary to produce solidification of cytoplasm and death. This explains why the critical temperature is minus 5° C. instead

of the theoretical (derived from crystalloid and protein content) minus 0·9° C., and also why very short exposures to much lower temperatures may produce little ill effect. The graph (Fig. 151) illustrates this effect.

The problem is rendered more complicated still by the fact that while superficial tissues may have passed the critical temperature the deeper structures may, owing to the body's various protective mechanisms, for long be kept above this limit.

Direct destruction of tissues by cold beyond the critical temperature will thus explain the cases of true frost-bite, but in view of the above findings this will not explain the pathology of such conditions as trench-foot, for here the exposure has never been beyond the critical point. As the result of a good deal of experimental work the conclusion was reached that in these cases the damage did not occur during the exposure but was the result of a violent reaction which occurred subsequently.

Reaction subsequent to exposure

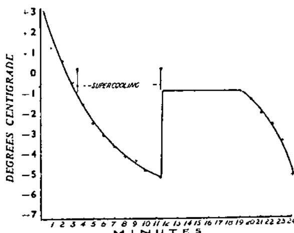


FIG. 151.—The cooling curve of fresh rabbit muscle, plotted against time. The external cooling medium remained at an almost constant temperature during the course of the experiment. Super-cooling is displayed between the points marked. When the muscle temperature reaches −5° C. there is a sudden rise to the theoretical freezing-point and the protoplasmic structure is disrupted (Lake, 1917).

Of the elements of this reaction the vascular response seems to be the most important, for both in the experimental animal and in human cases a tremendous transudation of fibrinous exudate occurs from the vessels during the thaw period which may be under sufficient tension to cut off the blood supply to the surface, or to digits, and so produce gangrene. It was found (Lake, 1917) that if the exudation could be prevented by various measures of vasoconstriction or, paradoxically enough, by tying the main artery to the limb, gangrene did not result in the experimental animal. Similarly multiple punctures or small incisions which allowed the exudation to escape were effective. Interference with the nerve supply, whether somatic or sympathetic, did not prevent gangrene; indeed in the case of the latter the results often seemed to be more severe. These experiments were repeated, as far as was feasible, on human skin with the same results.

Gangrene prevented

Not all observers agree that true frost-bite and trench-foot are of separate pathology (Smith, Ritchie and Dawson, 1915; Greene, 1943), although few would deny that they are aetiologically different; this was recognized in the Napoleonic and Crimean campaigns, and was amply confirmed in World War I and by the experiences of high mountain and polar expeditions.

Short of actual gangrene there are effects upon various tissues which are almost certainly related to the exudation or to its subsequent organization. Thus the skin and subcutaneous fat become sclerosed; the nervous lesions

have been studied clinically by Ungley and Blackwood (1942), who attributed them chiefly to relative ischaemia during the thaw period.

To sum up the pathology of the cryopathies it would seem reasonable to conclude that there are two distinct types, true frost-bite and the effects of chilling (trench-foot, immersion-foot, etc.). In the former, except in very transient exposures, the damage is immediate and irreversible; nothing that can be done subsequently can save the destroyed tissues. In trench-foot, on the other hand, the tissues are still alive at the end of the exposure but may suffer at the thaw from swelling and associated ischaemia. For reasons given above the pathology is not infrequently a dual one. *Dual pathology*

3. TRUE FROST-BITE

The aetiological factor is intense cold below the critical temperature when the atmosphere will of necessity be quite dry. Such conditions arise on mountaineering and polar expeditions, in high flying at times, and of course normally in certain regions such as Siberia and Canada. Clothed parts are fairly well protected from dry cold, but the hands, face, nose and ears suffer. Wind is an important additional factor (Brahdy, 1935). Greene (1941) from his mountain experiences thus describes the onset: "a sting like that of a wasp is usually felt (especially on contact with cold metal), but sometimes it is painless. The skin is white and crystalline. If it is observed at once and a warm hand clapped on it no harm may be done . . . If freezing continues, there is destruction of tissue, blood-vessels give way, oedema and haemorrhage develop and the vitality is destroyed . . . A frost-bitten hand may have precisely the appearance of a case of arterial embolism . . . Later the unviable tissues become black, hard and painless."

Even in the milder cases when there is little loss of tissue there may be long-lasting disturbances of sensation, anaesthesia, paraesthesiae, and hyper-aesthesia. From the prognostic point of view, however, it is to be remembered that the frost-bitten part commonly looks worse than it really is, since, as would be expected, the most intense effect is a surface one. *Intense surface effect*

The method of prevention of true frost-bite has been learned in the hard school of experience, but guidance has also been obtained from observation of the traditional methods adopted by dwellers in arctic regions, such as Eskimoes. Clothing should be in as many layers as possible; wool, despite substitutes, is still the best material. The outermost layer must be impervious to wind but light, flexible and robust. Leather is suitable (hence the fur-lined coat); Grenfell cloth has also proved satisfactory. Above all, clothing must not be tight, especially socks and boots. In the case of airmen the provision of enclosed cabins and electrically heated suits has removed the risk of frost-bite except when damage to the plane has rendered these aids ineffective. For those whose exposure is likely to be prolonged (explorers and the like) the question of an adequate food supply of high fat and carbohydrate content and of supplementary vitamins is extremely important. Shortage of vitamin C was one of the factors concerned in the tragic outcome of the Scott polar expedition. *Adequate food supply*

Treatment

For obvious reasons the treatment of true frost-bite usually starts long before the sufferer comes under medical care; all those open to the risk should therefore

have knowledge of a few elementary principles. Except for a momentary attack, such as that described above, the thawing must be done very slowly. No artificial heat should be used; the part, protected from further exposure, is allowed to revive as the returning circulation brings in the body heat. Greene (1940) rightly stresses that there should be no rubbing since the skin is in a most delicate state. The general body heat must be sustained by food and hot drinks of good calorific value. In mild cases recovery may occur with mere desquamation of the skin. Severe cases will leave denuded areas very like a burn which may require grafting. Residual lesions are dealt with on ordinary orthopaedic principles, bearing in mind that the surrounding tissues are in a poor nutritional state and provide poor material for the fashioning of flaps and so on.

Probable secondary infection

It may here be interpolated that in all the cryopathies secondary infection is likely unless due precautions are taken; in particular, on account of the anoxaemia, tetanus is prone to fulminate so that antiserum should be given in all cases.

4. TRENCH-FOOT

Here the exposure is to temperatures which are never lower than minus 1·9° C. (the freezing-point of sea-water) and frequently may be a little above zero. The surrounding conditions are thus wet cold, and in consequence the feet suffer most, knees and hands being rarely affected. The onset often attracts little attention since the part slowly becomes insensitive, but if the temperature is variable, pain and discomfort may be felt. On removal from the provocative environment (at the end of a spell in the trenches or upon sea rescue) there is rapid swelling with a dusky-blue pallor followed by intense flushing. This is the stage of maximum pain, and when most damage occurs from wrongful handling. In slight cases, after a few days the swelling subsides, perhaps with superficial desquamation. In severe cases the swelling increases until the whole foot looks like a pudding, blisters form and gangrene of portions of skin or of digits follows. To the uninitiated it appears that the whole foot is doomed, yet such a foot may recover after a long period with some loss of skin and digits. In the most severe cases the foot ultimately turns dark blue or black and again shrinks as deep gangrene occurs up to a line of demarcation at about the ankle level. As in true frost-bite, however, the condition usually looks worse than it really is. In cases where the foot is saved there is apt to be sclerosis of skin and subcutaneous tissues with stiffening of joints, increased sensitivity to further exposure to cold and, most important, a complicated set of sensory changes with paraesthesiae, due to effects upon the nerves which have been carefully studied by Ungley and Blackwood (1942).

Treatment

Since we are dealing with wet cold, and water is a good thermal conductor, prevention will be best achieved by the wearing of long waterproof boots inside which the feet can be kept warm by wearing several pairs of stockings. Leather can be kept waterproof if well oiled, but rubber gum boots are more practicable. Unfortunately watertight materials retain sweat and, if this is excessive, may defeat their object. In conditions of inactive trench warfare this is, however, rather unlikely.

If stockings get wet they must be replaced by dry ones. Trenches should be

well drained, and provided with platforms or duckboards to keep the man out of the slush. Movement of the legs should be encouraged and sitting with the legs dependent prohibited. Tight clothing (puttees, etc.) is to be avoided. Alcohol as a peripheral vasodilator is not contra-indicated if the feet are dry, *but tobacco in excess in some men produces the opposite effect and is to be* banned. As in true frost-bite diet is of importance, but rubbing with oil is probably of small value.

When exposure has occurred the greatest care must be taken during the thaw period. The general principles given above for true frost-bite apply here also, but in addition every effort must be made to limit the exudation, and any method directed to this end, whether orthodox or not, is worth a trial. *Certainly the limb must be really well elevated for a considerable time. In this* stage all vasodilators are to be avoided: vasoconstrictors, and all materials that diminish capillary permeability, are logical. Hypertonics intravenously and diuretics may be used and, if sterility can be guaranteed, multiple punctures or small incisions may enable the exudate to escape and so save tissue. In my opinion sympathectomy is contra-indicated at this stage although it may have some value in the late sequelae. Similarly all forms of heat treatment *should be avoided in the early stages. Amputation of the foot is rarely neces-*sary but individual toes may separate spontaneously. Occasionally late amputation may be required when sclerosis of tissues has produced grave disability. The persistence of nervous lesions is a further cause of late disability. *Care on thawing*

BIBLIOGRAPHY AND REFERENCES

Allen, F. M. (1938). *Surg. Gynec. Obstet.*, **67**, 746.

Andrews, F. W. (1923). *Official History of the War (Medical Services) Pathology*, p. 195. London; H.M. Stationery Office.

Brahdy, H. (1935). *J. Amer. med. Ass.*, **104**, 529.

Greene, R. (1940). *Lancet*, **1**, 303.

— (1941). *Ibid.*, **2**, 689.

— (1943). *J. Path. Bact.*, **55**, 259.

Knight, B. W. (1940). *Brit. med. J.*, **2**, 610.

Lake, N. C. (1917). *Lancet*, **2**, 557.

— (1918). *Report to War Office upon Frost-bite and Trench-foot.* Privately circulated.

— (1942). *Surgery of Modern Warfare.* Ed. by H. Bailey, 2nd ed., Vol. 2, Chap. 41. Edinburgh; Livingstone.

— (1943). *The Foot*, 3rd ed., p. 323. London; Baillière.

Larrey, D. J. (1812). *Mémoires de Chirurgie Militaire et Campagnes*, Vol. 3, p. 60.

Lewis, T. (1941). *Brit. med. J.*, **2**, 795.

— and Love, W. S. (1926). *Heart*, **13**, 27.

Medical History of the Crimean War, Vol. 2, p. 187. (1858). London.

Smith, J. L., Ritchie, J., and Dawson, J. (1915). *J. Path. Bact.*, **20**, 159.

Ungley, C. C., and Blackwood, W. (1942). *Lancet*, **2**, 447.

[References to other titles are given under Frost-bite in the Index Volume. The subject is also dealt with under the heading of Frost-bite and Trench-foot in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 440.]

GALL-BLADDER AND BILE PASSAGES

By J. B. OLDHAM, V.R.D., F.R.C.S.
Surgeon, Royal Liverpool United Hospital; Lecturer in Surgery, University of Liverpool

1. ANATOMY

(1) Gall-bladder

161.] Variations from the normal anatomy are so frequent—according to Flint (1923) they occur in 70 per cent of patients—that the surgeon must in every operation identify (1) the cystic artery as it reaches the gall-bladder, and (2) the junction of the cystic duct with the hepatic and common bile-ducts, before the artery or the duct is ligated. *Anomalies of ducts and vessels*

Most of the rich lymphatic drainage converges on the cystic lymph gland—the sentinel gland—which lies close to the cystic artery and is invariably enlarged in infections of the gall-bladder. Some of the lymphatics pass directly into the liver, across the bare area of the gall-bladder wall; this explains the localized hepatitis so constantly found in the region of the gall-bladder in cholecystitis. *Lymphatics*

(2) Bile-ducts

The sphincter of Oddi at the lower end of the common bile-duct has only recently been recognized as a separate anatomical and functional entity, and its part in the clinical physiology of diseases of the biliary tract is still not fully understood. The surgeon will do well to remember that the duct in its supra-duodenal portion may sometimes lie more horizontal than vertical to the long axis of the patient's body. *Sphincter of Oddi*

2. PHYSIOLOGY

The only known function of the gall-bladder is to serve as a reservoir for the bile that is secreted during the inter-digestive period; this it can do, in spite of its limited capacity (50 cubic centimetres), on account of its power to concentrate the bile. After food is eaten there is a reciprocal action between the sphincter at the duodenal end of the duct and the gall-bladder. The tone of the

Cholecystokinin

sphincter is decreased by the passage of the gastric contents into the duodenum; at the same time a hormone—cholecystokinin—is released by the duodenal mucosa, is absorbed into the blood, and stimulates the gall-bladder to contract.

"White bile"

In obstruction of the common bile-duct the pressure in the duct rises until the liver is no longer able to secrete bile. The bile in the ducts is absorbed and is replaced by the clear mucoid fluid secreted by the tubular glands in the duct walls—the so-called white bile.

3. DISEASES OF THE GALL-BLADDER

(1) Acute cholecystitis

(a) *Aetiology*

Association with gall-stones

In the great majority of cases of acute cholecystitis the condition is primarily and mainly obstructive, and bacteria play only a minor role. The commonest, as well as the most severe, forms of acute cholecystitis are associated with the presence of gall-stones.

Typhoid fever

A small proportion of cases are due to infections, and of these the most important are typhoid and paratyphoid fever. Though the gall-bladder lesion usually starts between the seventh and thirtieth days of the fever the organisms may remain latent and set up acute cholecystitis years later. Low-grade or latent typhoidal cholecystitis may continue for years, and it is this group which is responsible for many typhoid carriers.

(b) *Morbid anatomy*

Oedema

In the great majority of cases the gall-bladder contains gall-stones. The most striking feature is a marked inflammatory oedema especially in the serous and subserous layers. The mucosa is a bright red colour, the serosa is congested and often covered with fibrin. If the obstruction of the cystic duct is complete the gall-bladder may be distended with what appears to be purulent fluid—

Empyema of gall-bladder

empyema of the gall-bladder. If this fluid is examined microscopically, however, it will generally be found to consist not of pus but of an emulsion of cholesterol and calcium carbonate; this explains the relatively benign nature of most cases of acute cholecystitis.

Gangrene

In a small percentage of cases, when occlusion of the cystic duct is associated with the presence of highly virulent organisms, gangrene of the gall-bladder may occur, and a similar termination is common in typhoidal cholecystitis. Neglected suppuration and gangrene of the gall-bladder are extremely serious conditions and may result in local abscess, peritonitis, perforation or fistulous connexions with the bowel.

The organisms present in acute cholecystitis are usually *Bacillus coli* or streptococci, less often *Bacillus welchii* or *Bacillus typhosus*.

(c) *Clinical picture*

History of dyspepsia

There is frequently a history of flatulent dyspepsia and possibly of biliary colic, with or without jaundice. The pain in the attack may be either a constant ache—localized in the region of the gall-bladder or diffuse over the right side—or a colicky pain radiating to the lower angle of the right scapula.

Tenderness

Vomiting is a variable feature, but tenderness over the gall-bladder is constant and is usually associated with muscular resistance. Fever is common and

varies between 100° and 103° F., but if the common bile-duct is infected it may be higher and be associated with rigors.

As in other lesions of the gall-bladder there is no real relationship between the severity of the symptoms and the seriousness of the pathological findings.

(d) Differential diagnosis

In practice the main problems in the diagnosis of acute cholecystitis are:

(1) To rule out a perforated or penetrating peptic ulcer.

(2) To exclude other acute abdominal conditions such as appendicitis, pancreatitis or mesenteric thrombosis.

(3) To eliminate the possibility of coronary thrombosis.

Peptic ulcer With a peptic ulcer there is usually a long history of intermittent attacks of pain which were relieved by food and alkalis and, if the ulcer perforates, the muscular rigidity is more general and board-like, the liver dullness may be obliterated, and radiography may show air in the peritoneal cavity. *Appendicitis* Cholecystitis can be distinguished from acute appendicitis by a consideration of the previous history, by the location of the pain and resistance in the hypochondrium in the one case, and in the iliac fossa or loin in the other. If the enlarged gall-bladder can be felt it may be mistaken for an appendix abscess, but its continuity with the liver dullness will usually help in the differentiation. *Pancreatitis* Diagnosis from pancreatitis can be very difficult, but estimation of the urinary diastase may help.

Coronary thrombosis In coronary thrombosis males are more commonly involved and the pain is referred down the arm, seldom posteriorly as in cholecystitis. Falling blood-pressure, pericardial friction and electrocardiographic changes will indicate coronary thrombosis.

(e) Indication for surgical treatment

There is common agreement that operative treatment is indicated in all cases; but marked difference of opinion exists as to the best time for operation, and considerable judgement may be needed in deciding between cholecystostomy and cholecystectomy.

Immediate or delayed operation Until a few years ago the accepted plan was to treat all cases conservatively, and to await resolution of the acute attack before operating on the patient. Nowadays many surgeons are abandoning this policy and are operating on cases of acute cholecystitis as soon as possible after the diagnosis is made. There is much to be said for not delaying operation if the case is seen within 24 hours of the onset of the attack, but conservatism is indicated if the patient is very obese, feeble or aged, or if there are severe chest complications. If the patient is not seen until more than 24 hours after the onset of the attack, and especially if there are indications that the condition is settling, conservative measures carry the least risk. Operation must not be delayed if there is persistent pyrexia, tenderness or rigidity, severe pain, increasing pulse rate, toxaemia or leucocytosis.

Cholecystectomy or cholecystostomy In most cases cholecystectomy, combined if necessary with choledochostomy, is indicated for it removes the infected useless gall-bladder, gives a smoother convalescence and avoids the need for a further operation. The necessity for being content with cholecystostomy is obvious when (1) the condition of the patient is so grave that only the simplest and quickest operation can be considered, (2) when the adhesions and oedema make cholecystectomy particularly difficult or (3) when there is associated jaundice—for

separation of the inflamed gall-bladder from the liver might then cause severe bleeding.

(f) Results of surgical treatment

At least 80 per cent of cases of acute cholecystitis treated conservatively will settle down, and the gall-bladder can later be removed with relatively little risk. The mortality rate of operations performed during the first day is not more than 5 per cent in the hands of expert surgeons, but operation later in the acute attack—especially on the third, fourth or fifth days—carries a very high mortality. A relatively high percentage of patients treated by cholecystostomy will continue to have symptoms, and from 10 to 30 per cent of these will require further operation.

Mortality

(2) Chronic cholecystitis and gall-stones

The subjects of chronic cholecystitis and gall-stones are so interrelated both from a clinical and a pathological standpoint that they will be considered together.

(a) Aetiology

As a rule chronic cholecystitis is not a legacy of acute cholecystitis but a distinct disease. It may precede gall-stones or may follow them as a result of their irritant and obstructive effects. Post-mortem examination of gall-bladders shows some degree of cholecystitis in 60–75 per cent, but probably not more than 10 per cent of these produce clinical symptoms. Two varieties of chronic cholecystitis may be considered: (1) an inflammatory type and (2) a metabolic form.

Incidence

We cannot yet say that the problem of calculus formation has been solved. Three factors have to be considered: (1) bacterial infection, (2) stasis of the bile and (3) a high cholesterol content of the bile. The importance of the part played by each of these factors differs with the various types of stones. Infection is probably the most important factor, though in some cases it plays no part. The solubility of the cholesterol and bile pigments in the bile is maintained by the bile salts; if the bile salts are removed the cholesterol is precipitated. The cholesterol and bile salts are absorbed equally from the normal gall-bladder, but an infected gall-bladder absorbs bile salts rapidly and cholesterol slowly, if at all.

Role of infection

(b) Morbid anatomy

Early signs

The healthy gall-bladder is translucent and transmits the deep blue-green colour of the bile within it. The earliest sign of disease is the replacement of this translucency by a faint opacity which often shows up first near the neck of the gall-bladder. Other early changes are: (1) a slight increase in the subserous fat, (2) enlargement of the cystic lymph gland and (3) subcapsular fibrosis of the liver round the gall-bladder.

In the later stages of cholecystitis the wall of the gall-bladder becomes obviously thickened and pearly-white in colour. The gall-bladder may become dilated, especially if the cystic duct is obstructed by a stone or by fibrosis, and then is filled with clear, colourless fluid—hydrops of the gall-bladder—or it may contract down to a firm fibrous mass. If it becomes distended, a curved pouch-like portion of the gall-bladder is often found bulging down, overhanging the cystic duct and perhaps becoming adherent to the

common bile-duct which is then very liable to be injured during cholecystectomy.

Cholesterosis Cholesterosis of the gall-bladder—or "strawberry gall-bladder"—is the best-known type of cholecystitis resulting from metabolic changes. It is characterized by the deposition of large amounts of esters of cholesterol in the mucous membrane, where they form small yellow specks like the seeds of strawberries, or larger masses—lipoid polypi. The condition is strictly limited to the mucous membrane of the gall-bladder itself. The villi of the mucosa, normally thin and tenuous, are swollen with lipoid material. There is little change in the external coats, and inspection of the unopened gall-bladder generally shows little evidence of pathological change. Stones are present in half of the cases and are usually of the pure cholesterol type.

Two main types of gall-stones may be recognized: (1) metabolic or aseptic stones and (2) inflammatory or septic stones.

Cholestero stones Cholesterol stones are large, oval and whitish. They are distinguished by their radiate structure, as opposed to the concentric or laminated structure of the inflammatory or mixed stone. They are commonly associated with cholesterosis but may be found in a perfectly healthy gall-bladder. They are usually single and smooth, but may be multiple and lobular like unripe mulberries. If the stone becomes impacted in the cystic duct the resulting acute stasis is often followed by infection. When the obstruction is freed, and bile re-enters the gall-bladder, a deposit of calcium bilirubin is laid down on the cholesterol stone, producing a so-called "combination" stone. *"Combination" stone* Combination stones being partly infective in origin are often associated with multiple septic or mixed stones.

Pigment stone Pure pigment stones are rare, small, black, hard and brittle. They occur in cases in which there is an excess of pigment in the bile, as in haemolytic jaundice. They may form nuclei for the formation of cholesterol stones.

"Mixed" stones The infective or "mixed" stones are much the commonest type of gall-stone. They are multiple, faceted and, on section, show a characteristic concentric arrangement of laminae. They are usually all of one size, but sometimes there are two or more groups of different sizes suggesting that the factors for the formation of gall-stones are periodic rather than continuous.

Gall-stones of the ordinary type are always associated with cholecystitis. In general, the pathological lesions are those of non-calculus cholecystitis already described, with the added feature of a foreign body which may obstruct the emptying of the gall-bladder or incite an inflammatory reaction. As a result there is a progressive destruction of the mucosa and thickening and fibrosis of the wall of the bladder which is frequently contracted down upon its contents. On the other hand, empyema of the gall-bladder is not uncommon.

Complications of gall-stones Stones may enter the common bile-duct and produce jaundice or cholangitis, or by ulcerating through the gall-bladder wall a stone may give rise to a fistula through which it will enter the bowel and cause intestinal obstruction.

(c) *Bacteriology*

Organisms Cultures of the bile even from grossly diseased gall-bladders are usually sterile, for the bile has a mild inhibiting effect upon the growth of organisms. The gall-bladder wall, however, yields a growth in from 50 to 70 per cent of

cases. The organisms most commonly found are streptococci or *B. coli*. The streptococci are not virulent and are either *Streptococcus salivarius* or *Streptococcus faecalis*.

Route of infection

It is probable that the infecting organisms in most cases reach the gall-bladder through the portal blood stream, passing from the liver to the gall-bladder through the lymphatic channels in the hepatic capsule. Occasionally, the systemic blood stream may infect the gall-bladder from some distant focus.

(*d*) *Clinical picture*

Females

Cholecystitis and gall-stones are rare in young subjects and are far more common in women than in men, and in stout rather than in thin patients. The rise in the blood cholesterol during pregnancy is usually regarded as an aetiological factor.

Flatulence

The symptoms attributed to the condition are variable in the extreme. The most reliable and consistent symptom is recurrent flatulent dyspepsia usually associated with dull pain and discomfort in the epigastrium or right hypochondrium. Bloating after meals relieved by belching is a common complaint.

Pain

The patient often complains of pain below the angle of the right scapula, beneath the right ribs or in the right flank. The pain is usually constant and dull but aggravated immediately after taking food. Many patients are aware that their distress is made worse by fried or greasy food, roughage or coffee.

Although achlorhydria is common, heartburn is present in half the cases. Jaundice occurs in nearly 20 per cent of cases.

Biliary colic

Biliary colic is the most striking of all the clinical symptoms and in its typical form cannot be mistaken. It is common with gall-stones but occurs in only about a quarter of the cases of non-calculus cholecystitis. Frequently the colic is preceded by a chilly feeling in the back. The usual site of origin is the epigastrium; the sharper pain, starting in the right hypochondrium and extending to the scapula, occurs later as the result of inflammation causing a peritoneo-cutaneous reflex. Extension of pain to the right shoulder is uncommon. Retching is frequent but persistent vomiting suggests that the stone is in the common bile-duct. The pain is often made worse by small doses of morphine.

Radiation

Signs

The physical signs are few and indefinite, except when an empyema or hydrops produces a tumour. After acute exacerbations of the disease there is often tenderness in the region of the gall-bladder, and fever and leucocytosis are common.

(*e*) *Diagnosis*

As in most intestinal disorders the diagnosis of cholecystitis and cholelithiasis depends primarily upon an adequate history. The main importance of physical examination and laboratory tests is in excluding conditions likely to be mistaken for diseases of the gall-bladder. The value of cholecystography is discussed elsewhere (p. 245). Too much importance must not be attached to a report of "poorly functioning gall-bladder", nor must radiological examination stop when it has shown the presence of gall-stones unless the history is that of a lesion of the gall-bladder and of that alone.

(*f*) *Differential diagnosis*

Peptic ulceration frequently mimics diseases of the biliary tract. The poor response to standard methods of treatment of ulcer and the less clear

periodicity usually serve to exclude peptic ulceration. The patient with gall-bladder disease, moreover, immediately regrets, instead of obtaining temporary relief from, a heavy meal.

Diseases of the urinary tract can generally be differentiated by examination of the urine and by pyelography.

Coronary thrombosis may imitate gall-bladder disease; the differential diagnosis has already been discussed (p. 241).

The abdominal crises of *Tabes dorsalis* may simulate biliary disease but diagnosis should not be difficult if the possibility is kept in mind.

Chronic appendicitis is so commonly associated with cholecystitis that its presence may be almost taken for granted.

The differentiation between gall-stones and non-calculus cholecystitis may be very difficult. We may be certain that gall-stones are present if there are typical shadows on the x-ray films; reasonably certain if cholecystography shows a functionless gall-bladder, and fairly certain if there is a history of biliary colic followed by jaundice. The diagnosis of non-calculus cholecystitis is usually made when the symptoms, though suggestive of biliary disease, are mild and the cholecystographic evidence is equivocal.

(*g*) *Indications for surgical treatment*

Walters and Snell (1940) give the following indications for operative treatment in chronic cholecystic disease: (1) a satisfactory account of biliary colic or upper abdominal pain resembling colic; (2) residual tenderness or a palpable gall-bladder following such an attack; (3) persistent intractable dyspepsia unrelieved by ordinary measures; (4) cholecystographic evidence of loss of function of the gall-bladder or the presence of stones; (5) exclusion of conditions which simulate cholecystitis. When all these criteria are fulfilled the indication for surgery is clear. Difficulty arises when all of the indications are not satisfied. In such cases if the need for operation is not obvious, if the symptomatology is blurred or if we have made the diagnosis mainly on the evidence of cholecystography, then it is wiser to postpone operation, to give a good trial to medical treatment and to consider the case later. The more severe the symptoms, the more definite the diagnosis, and the more obvious the need for surgery the better will be the results obtained by operation.

Non-calculus cholecystitis

Cases of non-calculus cholecystitis probably present the most difficult problem. The existence of the condition is undeniable, but its treatment by surgery is so frequently followed by disappointing results that operation should be advised only with great caution. Pain, especially colic, is the most important feature justifying operation in these cases; if it is absent then cholecystectomy is likely to be followed by unsatisfactory results in at least 30 per cent of cases. Symptoms such as dyspepsia, bloating and so on are unlikely to disappear after operation unless the pathological changes in the gall-bladder are very definite. The more experienced the surgeon, the less ready he is to remove a gall-bladder which is not obviously diseased.

"Silent" gall-stones

What advice should we give to a patient who has positive radiological evidence of gall-stones, but who has few or no symptoms? It is true that many patients go through life unaware that they have gall-stones, and troubled little or not at all by their presence, but it is equally true that "innocent gall-stones

are a myth" (Mayo, 1911). It is impossible to predict how long a stone will remain silent—all too often the signs and symptoms give no real indication of the degree of pathological change. For these reasons, and because gall-stones and cholecystitis play a most important part in the causation of carcinoma of the gall-bladder, gall-stones generally should be removed at the earliest opportunity. The decision to operate or not will, of course, be influenced by such factors as the patient's age and general fitness.

Choice of operation

Cholecystectomy is the operation of choice. The indications for cholecystostomy in the treatment of chronic cholecystitis are precisely the same as in the acute form of the disease—the condition of the patient precluding anything but the simplest operation, the presence of adhesions and oedema, or of associated jaundice (*see* p. 241).

(*h*) *Results of surgical treatment*

Mortality

Late results

Cholecystectomy.—The mortality of cholecystectomy for chronic cholecystitis or gall-stones varies from 0·5 to 3 per cent. The late results show that 80 per cent of patients are cured; some 15 per cent are greatly improved, but have post-operative flatulence, chronic dyspepsia or even slight colic.

The results of cholecystectomy in non-calculus cholecystitis have already been described.

Cholecystostomy.—The results of cholecystostomy are not nearly so good; not more than 60 per cent of cases are cured, and in about a fifth of the cases further operation is needed.

(3) Carcinoma of the gall-bladder

(*a*) *Aetiology*

Carcinoma of the gall-bladder is relatively rare and there are signs that it is becoming rarer—possibly as the result of earlier recognition and treatment of gall-stones. It is an end result of chronic cholecystitis and in 75 to 90 per cent of cases gall-stones are present.

Gall-stones

(*b*) *Morbid anatomy*

Rapid spread

Carcinoma of the gall-bladder soon spreads beyond the organ. It involves the liver by direct continuity and spreads to the lymph glands along the biliary ducts, producing jaundice. Distant metastases—apart from those in the lung—are rare. The commonest type of growth is a scirrhous columnar-celled adenocarcinoma. Less common varieties are the papillary or the colloid carcinomas and rarest of all is a squamous epithelioma. All of these tumours are highly malignant.

Scirrhous adeno-carcinoma

(*c*) *Clinical picture*

The clinical symptoms and signs are very variable. In most cases the symptoms are those of cholecystitis and gall-stones. Later the pain becomes more constant and jaundice is common. In about one-third of the cases a hard, painful and irregular tumour may be felt in the region of the gall-bladder.

(*d*) *Diagnosis*

This is usually difficult and only made at operation.

(*e*) *Prognosis*

The prognosis is uniformly bad and few patients live more than a year after operation, and there is no evidence to suggest that the years have produced

any improvement either in diagnosis or treatment. The only good results are in those very rare cases in which the gall-bladder has been removed on a diagnosis of cholecystitis, and carcinoma has not been suspected until the organ was opened.

(f) Indications for operation

The indications for operation are very few, for by the time a diagnosis of *carcinoma has been made the liver is almost certainly invaded*, and in such cases cholecystectomy not only is of no avail but seems to hasten the fatal outcome. The only lesson to be learnt from the study of carcinoma of the gall-bladder is that early removal of gall-stones will reduce the incidence of this condition. *Prophylaxis*

4. DISEASES OF THE BILE-DUCTS

Lesions of the extra-hepatic bile-ducts may show themselves in three ways: (1) by obstruction to the flow of bile, with consequent jaundice, (2) by infection of the walls of the ducts—cholangitis, and (3) by functional motor disturbances—biliary dyskinesia.

(1) Obstruction of the bile-ducts

The cause of obstruction of the bile-ducts may be: (1) in the lumen (gall-stones, tumour), (2) in the wall of the duct (congenital or acquired stricture, choledochus cyst), and (3) outside the duct (carcinoma of the head of the pancreas, malignant glands, chronic pancreatitis).

(a) Morbid anatomy and physiology

The results of obstruction of the bile-ducts depend upon the completeness and rapidity of the obstruction and still more upon the presence of pre-existent inflammation causing fibrosis of the gall-bladder and bile-ducts. The effect of obstruction is threefold: (1) hydrohepatosis, (2) formation of "white bile", and (3) jaundice.

(i) *Hydrohepatosis—Courvoisier's Law.*—Obstruction to the flow of bile results in a widespread dilatation of the entire biliary tree. Malignant obstruction, which is usually complete, permanent and uncomplicated by cholangitis, gives rise to *tremendous dilatation of the gall-bladder and extra-hepatic and* intra-hepatic ducts with consequent atrophy of the hepatic substance. Stone in the common bile-duct is usually associated with dilatation of the extra-hepatic ducts, but relatively little distension of the intra-hepatic ducts, which are fibrosed by cholangitis, and the gall-bladder is thick-walled and contracted.

There is evidence that toxins, due to the degeneration of the parenchymal cells of the liver as a result of the hepatosis, may be flooded into the circulation if the biliary obstruction is suddenly released at operation, and the normal portal blood flow restored. The condition bears some resemblance in its aetiology and seriousness to the effect of sudden decompression of the distended urinary bladder. *Need for gradual decompression*

(ii) *"White bile" formation.*—When the back pressure in the ducts becomes high enough (300 millimetres of water) the secretion of bile ceases and the bile already in the ducts becomes absorbed. The glands in the walls of the bile-ducts continue to secrete and the ducts thus become filled with clear, thin, mucoid fluid.

(iii) *Obstructive jaundice.*—If the bilirubin of the bile cannot pass into the duodenum it is reabsorbed into the blood stream where it gives a positive direct van den Bergh reaction, in contrast to the indirect reaction in haemolytic jaundice. The excess bilirubin in the blood causes jaundice. If the obstruction is of long standing, there is impairment of liver function, mainly owing to the pressure of the dilated bile-ducts on the hepatic cells. Exclusion of the bile from the alimentary canal causes decreased absorption of fats, fat-soluble vitamins and some minerals such as calcium. The diminution in the absorption of the fat-soluble vitamin K results in decreased prothrombin production and lowered coagulability of the blood. These changes are of vital importance to the surgeon as they determine the surgical risk of operation.

Direct van den Bergh reaction

Diminished coagulation

There are other physiological disturbances associated with obstructive jaundice too imperfectly understood to warrant description here.

(*b*) *Choledocholithiasis*

(i) *Aetiology.*—Stones in the bile-ducts are much the commonest form of obstruction of the ducts. Whereas a few of these stones may arise in the ducts, the great majority have their origin in the gall-bladder. It has been estimated that some 13 to 20 per cent of patients with stones in the gall-bladder also have stones in the bile-ducts.

Origin of stones

Number

Site

Cholangitis

(ii) *Morbid anatomy.*—The number of stones is not usually large, indeed in 2 out of every 3 cases only one stone is found in the bile-ducts. In the majority of cases the stones are confined to the lower end of the common bile-duct. Stones in the hepatic duct are uncommon and intra-hepatic stones are very rare. Some degree of cholangitis is always present. The duct is more or less dilated, its walls thickened and opaque and the bile in it is generally muddy.

Intermittent pain and jaundice

(iii) *Clinical picture.*—The classical triad of clinical symptoms associated with stones in the bile-ducts is biliary colic, jaundice and fever. The ball-valve feature of calculus obstruction is responsible for the usual intermittent character of the pain and jaundice, but there is commonly a persistent gaseous dyspepsia after meals. The biliary colic is likely to be more severe and persistent than is the colic due to stones in the gall-bladder, and it is more often associated with vomiting. Though entire absence of pain is very uncommon, true colic occurs in no more than 75 per cent of cases. Jaundice, too, is not constant (75 per cent), and fever—the third cardinal feature—is noted in only 25 per cent of patients.

Few signs

Apart from the jaundice there are no physical signs of any value. In two-thirds of the cases the jaundice is slight and transient and the hepatic functional tests reveal nothing of importance.

Mortality

Late results

(iv) *Results of surgical treatment.*—The results of operative treatment for stones in the common bile-duct depend upon the presence and severity of the jaundice. If there is no jaundice the mortality should not exceed 3 per cent. If there is only slight jaundice the death rate should not be more than 6 per cent. In severe jaundice the mortality will be doubled—12 per cent—and if there is "white bile" probably 1 in 3 cases will not survive operation. The late results in cases uncomplicated by jaundice are excellent. If there is associated damage to the liver or pancreas the results, though not quite so certain, are surprisingly good in the great majority of cases.

(c) Congenital lesions of the bile-ducts

(i) *Congenital stricture of the bile-ducts.*—Failure of the normal process of canalization of the bile-duct system is the probable explanation of these rare anomalies. The ducts may be completely absent or appear as fibrous cords. Obliteration of the cystic duct—the commonest form of stenosis—is of no clinical importance. The common bile-duct is the second, and the hepatic ducts the third most frequent site of obstruction. *Varieties*

The symptoms are those of obstructive jaundice.

The diagnosis, which is invariably made by exclusion, as there is no other likely cause of permanent and complete obstructive jaundice in the new-born child, is usually possible by the end of the second month of life. *Diagnosis*

Ladd (1935), whose authoritative papers on the subject should be read, found that 37 per cent of cases were amenable to surgical treatment. *Prognosis*

The principles of treatment are those governing the surgical treatment of acquired benign stricture. Choledochoduodenostomy is the operation of choice and, on account of the small size of the ducts, it is generally advisable to make the anastomosis over a small piece of tubing. *Treatment*

(ii) *Choledochus cyst (congenital cystic dilatation of the bile-duct).*—Dilatation of the extra-hepatic bile-ducts may be likened to congenital hydronephrosis, oesophageal achalasia or Hirschsprung's disease, but no completely satisfactory explanation of the condition is available. *Aetiology*

The cystic dilatation, which may reach an enormous size, is usually confined to the supraduodenal portion of the common bile-duct.

The condition is very rare, is commoner in girls, and generally gives rise to symptoms before the age of 10 years but sometimes, as in two personal cases, it remains latent until adult life. *Clinical picture*

Colicky pain, intermittent jaundice and a cystic tumour in the right hypochondrium, displacing the stomach to the left and the duodenum and colon downwards, may suggest the diagnosis, but pre-operative diagnosis is rarely made. *Diagnosis*

Operative treatment is indicated in all cases and should consist of an anastomosis between the cyst and the duodenum. The results of this type of operation are remarkably good and cholangitis is a rare sequel. *Treatment*

(d) Acquired stricture of the bile-ducts

Rarely are injuries of any structure attended by such distressing and serious complications as are injuries to the bile-ducts. Though it is true that stricture of the bile-ducts may occasionally be due to non-traumatic causes, practically all follow injuries during cholecystectomy.

The frequency of anatomical anomalies of the bile-ducts is no excuse for these disasters and the surgeon must avoid them by ensuring good exposure, by never forgetting the frequency with which variations from normal occur, and by making it a rule never to clamp, tie or divide anything in this region until it has been identified beyond all doubt. He must "work by sight and not by faith" (Maingot, 1940). *Prophylaxis*

In particular, care should be taken (1) when for any reason retrograde cholecystectomy is being performed, (2) when the gall-bladder is very mobile and the operation seems very easy; traction on the bladder may draw the common duct out as a knuckle which may be easily clamped, and (3) if

haemorrhage occurs from the biliary vessels. Blind clamping must be avoided; the bleeding can be controlled by grasping the structures in the free edge of the gastro-hepatic omentum between the left index finger in the foramen of Winslow and the thumb in front.

Treatment

The treatment of established stricture of the bile-ducts is one of the most difficult tasks in surgery, a task which should not be undertaken except by surgeons skilled in biliary surgery, and with every possible aid and assistance at hand. Apart from the technical difficulties, the surgeon has to face the dangers from damage to the liver function, and from residual infection of the ducts.

Results of treatment

The literature is full of accounts of different methods of reconstructing the ducts. Till recently these operations, even in the hands of master surgeons, have not produced cures in more than 50 per cent of cases; but recently, a number of striking successes have been reported following the reconstruction of the duct over vitallium tubes.

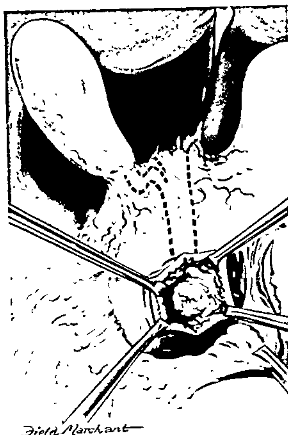


FIG. 152.—Carcinoma of ampulla of Vater. Note dilatation of bile-ducts and gall-bladder.

(e) *Neoplasms of the bile-ducts*

Aetiology

Benign tumours of the bile-ducts are exceedingly rare, but carcinomatous lesions are not uncommon. These tumours, unlike the carcinomas of the gall-bladder, are generally unassociated with gall-stones, and are as common in men as in women.

Site

The tumours may arise anywhere in the ducts but the ampulla of Vater is the commonest site (Fig. 152).

(i) *Morbid anatomy*.—The tumours of the ampulla of Vater appear as small circumscribed, purely local, movable lesions without extension to the surrounding tissues or distant metastases. Growths elsewhere in the ducts are usually of the annular scirrhus type. The gall-bladder is invariably enlarged if the obstruction is below the junction of the cystic and hepatic ducts and, more often than not, contains "white bile".

(ii) *Clinical picture*.—The clinical manifestations vary with the site of the tumour but all patients show marked obstructive jaundice, asthenia and cachexia. Carcinoma of the ampulla of Vater in addition to the jaundice shows evidence of pancreatic insufficiency from blockage of the duct of Wirsung, intestinal bleeding from ulceration of the growth

and marked secondary anaemia. Pain is very common and colic is not unknown.

(iii) *Prognosis.*—Rapid decline is the rule, with death inside 6 months. In view of the prognosis without treatment and the freedom from metastases, operative treatment is indicated except when there are obvious contra-indications.

(iv) *Treatment.*—If the growth is not removable, anastomosis of the gall-bladder to the jejunum by the Roux-in-Y method is indicated. If it is operable, transduodenal resection of the growth with a generous margin of the surrounding duodenum and the two ducts is indicated, followed by suture of the margins of the ducts to the cut edge of the duodenum. Internal or external biliary drainage may be established either at the same time as the excision or at a preliminary operation, but this is probably an unnecessary step.

(v) *Results of operation.*—The operative mortality for palliative biliary drainage is about 40 per cent, whereas transduodenal resection of the ampullary growth has about the same death rate. Recurrence after excision is common but many long-term survivals have been reported.

Tumours of the bile-ducts proximal to the ampulla do not, except at a very late stage, obstruct the pancreatic ducts. They can be treated by anastomosing the gall-bladder, or the duct above the obstruction, to the proximal jejunum, and if possible the tumour should be excised.

(*f*) *Diagnosis of conditions associated with jaundice*

"No man living is infallible in the diagnosis of obstructive jaundice"

(Moynihan).

The first essential in making the diagnosis of a case of jaundice is a complete history with especial reference to the time relationship of the jaundice to dyspepsia, previous operations or attacks of pain. The type and distribution of the pain must be carefully noted and inquiry made as to any exposure to hepatic toxic agents, especially cinchophen, alcohol or arsenic. The degree and shade of the jaundice may be important—the lemon-yellow hue of haemolytic jaundice distinguishing it from the orange jaundice of hepatic damage or the greenish hue of obstructive jaundice. *History* *Shade of jaundice*

Palpation of the liver and spleen is important. Splenomegaly is as rare in malignant obstructive jaundice as it is common in all kinds of hepatic lesions. Enlargement of the gall-bladder is almost invariable in malignant obstruction though very often (40 per cent) it is masked by enlargement of the liver. *Liver and spleen* *Gall-bladder*

(i) *Haemolytic jaundice.*—Haemolytic jaundice can usually be distinguished by the presence of: (1) an indirect van den Bergh reaction, (2) acholuria, (3) splenomegaly and (4) increased urobilin in the faeces and urine.

More than 30 per cent of patients with the most characteristic type of haemolytic jaundice—the familial type, which is associated with increased fragility of the red cells—eventually develop pigment stones in the bile-ducts, and obstructive jaundice. *Pigment stones*

(ii) *Hepatogenous jaundice.*—Hepatogenous jaundice is unassociated with pain. There is bile in the faeces and bile and urobilinogen in the urine. The jaundice varies and there is early evidence of hepatic disturbances (*see* Biochemical Tests in Vol. 2, p. 71).

It is a sound rule to consider all cases of jaundice as hepatogenous until they

are proved otherwise, for they are more likely to be harmed than helped by operative interference.

(iii) *Obstructive jaundice due to gall-stones.*—As in all other forms of obstructive jaundice, that due to stones is associated with a direct positive van den Bergh reaction. The degree of jaundice varies and there is no constant absence of bile from the faeces. Pain is rarely absent and, in at least 80 per cent, is a typical biliary colic. The rapid fluctuations in the serum-bilirubin values are very characteristic.

(iv) *Obstructive jaundice due to stricture.*—Except in the congenital cases there is almost always a history of previous operation on the gall-bladder. Pain is not uncommon but is seldom severe or colicky. Jaundice is constant but generally there is some bile in the duodenal contents.

(v) *Obstructive jaundice due to malignant disease.*—Though the jaundice of malignant obstruction of the bile-ducts is generally described as being painless, some form of pain is present in 40 per cent of patients. The jaundice is deep and constant, and the complete and permanent absence of bile from the faeces is practically pathognomonic. The gall-bladder is invariably enlarged, if, as is usually the case, the obstruction is below the entry of the cystic duct into the common duct. Hepatic damage is severe and cachexia and pruritis are marked.

(g) *Indications for operation in obstructive jaundice*

"*The diagnosis is always difficult and the chance of a life saved is so important that, however positive the evidence of malignancy, I have advised operation in all cases*" (Moynihan).

It is sound policy to explore the bile-ducts in all cases of painful, variable jaundice, in cases with a previous history of gall-stones, and in cases of complete biliary obstruction.

When to operate

The real difficulty in these cases is to know when to operate. Our aim should be to raise the patient's general condition and hepatic function to the highest possible level before operation. It is relatively easy to evaluate the general condition but much harder to judge the hepatic function. Though numerous tests have been devised for gauging the liver function, none of them replace clinical acumen.

In general, if the jaundice is due to gall-stones, operation may be deferred in the hope that the jaundice will lessen. If it does not recede within two weeks (as shown by an increase in the urobilinogen in the faeces and a decline in the serum-bilirubin value) then the common duct should be explored without further delay. In malignant obstruction operation should be undertaken just as soon as adequate pre-operative treatment can be given, for the chance of the jaundice receding is negligible. There is no denying the high immediate mortality and the poor ultimate prognosis in malignant jaundice, and the pessimist may say with some justification "Why not leave them alone? If I operate, then they die within 3 weeks but if I leave them alone they may live for 3–6 months". The crux of the matter is the difficulty in diagnosis. The jaundice may after all be due to some non-malignant condition amenable to surgery. If at operation the condition proves to be malignant an attempt should be made to relieve the biliary obstruction, for almost every patient will declare that the chance of relief from the intolerable pruritus is worth any risk or sacrifice.

(2) Cholangitis

Inflammation involving the walls and lumina of the extra-hepatic and intra-hepatic bile-ducts—cholangitis—is in most cases the result of stones or a stricture of the ducts. It may, however, occur in association with chronic cholecystic disease and in these cases it is difficult to say which is the primary lesion—the changes in the gall-bladder or the infection of the ducts and liver parenchyma.

Suppurative cholangitis usually results from the lighting up of a previous infection, and is almost always associated with obstruction of the bile flow. There is another group of cases associated with an ascending infection following anastomosis of the gall-bladder or bile-duct to the stomach or intestines.

(*a*) *Pathology*

The usual organisms are the colon group bacilli, the pyogenic cocci or the *Bacillus aerogenes capsulatus*. The liver is generally enlarged and shows multiple miliary abscesses. Splenomegaly is often noticeable.

(*b*) *Clinical picture*

The subacute and chronic forms of cholangitis together with the hepatitis which accompanies them do not present a definite recognizable clinical picture. Clinically, their main significance is their tendency to flare up in the presence of biliary obstruction, and to lead to further and more severe lesions of the finer ducts.

Suppurative cholangitis

Suppurative cholangitis presents a much more distinctive picture. The development of repeated spells of pyrexia and deepening jaundice in association with some obstructing lesion are almost pathognomonic. Progressive enlargement of the liver and leucocytosis are usual.

(*c*) *Treatment*

The treatment is essentially prophylactic—the early and adequate treatment of infected or calculous gall-bladders. If there are multiple abscesses the common bile-duct should be drained. In all cases chemotherapy should be used, and as *B. coli* and streptococci are the causal organisms, administration of penicillin and the sulphonamides is indicated.

(3) Biliary dyskinesia

Normally, there is a nicely balanced reciprocal activity between the gall-bladder and the sphincter of Oddi; increase in the activity of either of these will raise the intraductal pressure and cause pain. Usually after cholecystectomy there is a loss of tone of the sphincter and this is probably responsible for the relief of symptoms. Some unfortunate individuals after operation develop either an abnormal physiological response, or their symptoms have been due to a pre-existing dysfunction which has persisted after operation.

In these cases there is no jaundice, chills or fever. The pain is usually made worse by small doses of morphine, and is eased by amyl nitrite inhalations, or glyceryl trinitrate, grain $\frac{1}{100}$. *If conservative treatment fails prolonged* drainage of the common bile-duct may help.

5. PRE-OPERATIVE TREATMENT

(1) Acute cholecystitis

The conservative treatment of acute cholecystitis consists in nursing the patient in Fowler's position and forbidding all food by mouth. Small amounts

of water are allowed and the fluid balance is maintained by the intravenous route.

(2) Chronic diseases of the biliary tract unassociated with jaundice

There is rarely any urgency in these cases and they should be given careful preparation for operation. Any septic focus should be eradicated. Marked obesity should be reduced by diet and the use of thyroid extract in suitable cases.

Apart from the reduction of obesity there is no sound reason for withholding fats provided the patient can tolerate them. Usually most kinds of fats can be tolerated, but fried foods cause discomfort.

Next to fats, magnesium salts are the best cholagogue and should be given for at least a week before operation, in concentrated doses 1 hour before breakfast.

Biliary antiseptics

Hexamine is the most commonly used biliary antiseptic. It should be given in large doses (100 grains) with alkalis (sodium bicarbonate and sodium citrate, 60 grains of each) in water thrice daily. Amyl nitrite inhalations or nitroglycerin (grain $\frac{1}{100}$) or atropine by mouth may aid in relaxing the sphincter of Oddi and easing painful attacks of colic.

Anti-spasmodics

(3) Diseases of the biliary tract associated with jaundice

Diet

In no branch of surgery is pre-operative treatment more important than in the surgery of jaundice. The diet should possess a high protein (25 per cent) and carbohydrate (70 per cent) content and a low fat (5 per cent) content. A high calorie intake (2,500–3,000) should be aimed at and this will probably require intravenous glucose as well as oral feeding. The maintenance of water and electrolyte balance is essential, and a fluid intake and output record must be kept so that the amount of fluid given can be regulated in respect to the output of urine and its specific gravity. In addition to the amount they are able to take by mouth, most jaundiced patients will require 2,000 cubic centimetres of fluid containing 5 per cent glucose in normal saline daily, the quantity of saline being controlled by estimations of the urinary chlorides.

Water and salt balance

Blood transfusion

Blood transfusions are of great benefit to counteract the anoxaemia associated with hepatic degeneration and to improve coagulation.

Vitamins

Large amounts of the fat-soluble vitamins A and D should be given as cod-liver oil (3 drachms three times daily); or as one of the proprietary preparations. Vitamin C may be given as fresh orange juice or as ascorbic acid (0·05 gramme daily).

It must not be forgotten that in a disease which has loss of appetite as an outstanding symptom the paramount need is for the diet to be palatable.

Haemorrhage

Vitamin K

Almost half of all the deaths following operations on jaundiced patients are due to haemorrhage, and in all cases it is essential to correct the prothrombin deficiency in the blood. There are many proprietary brands of synthetic vitamin K (2-methyl-1 : 4-naphthoquinone) on the market, any of which may be used. From 5 to 10 milligrams of the drug should be given daily, by intramuscular injection, for 2–3 days before operation and for a similar period afterwards. In an emergency it may suffice to give the drug 6–12 hours before operation. In critically ill patients the normal dosage may be increased 2 to 4 times; no ill effects follow such increase. Blood transfusion is the quickest

way of replenishing the prothrombin content but fresh blood must be used, for with storage the prothrombin in the blood is destroyed.

6. OPERATIVE TECHNIQUE

(1) General

As in other abdominal operations success in the surgery of the gall-bladder and bile-ducts depends largely upon adequate exposure which, in its turn, is dependent upon the anaesthetic and the incision.

(a) Anaesthetic

The ideal is an anaesthetic which gives maximal relaxation, light but satisfactory anaesthesia and is not unduly embarrassing to the respiratory system. Tubocurarine chloride and Pentothal Sodium (Gray and Halton, 1946) fulfils *Curarine* these requirements more nearly than any other method. However, almost any form of anaesthesia other than chloroform may be used, depending upon the preference and experience of the anaesthetist.

(b) Incision

Two incisions are in common use; the right paramedian and Kocher's incision. The latter incision is particularly suitable in patients with a wide costal angle; when the angle is narrow a paramedian incision gives a better approach. Whatever type of incision is used it must be generous in length.

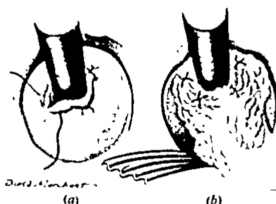
(c) Exploration of bile-ducts and abdominal viscera

The gall-bladder is carefully examined and then the common and hepatic ducts are palpated between the index finger—passed into the foramen of Winslow—and the thumb. The pancreas and the first part of the duodenum are palpated in the same way. The stomach, appendix and the rest of the abdominal and pelvic organs are then examined.

It is axiomatic that in any operation on the gall-bladder the hepatic and *Indications for opening common bile-duct* common bile-ducts must be examined. There is, however, a difference of opinion as to what constitutes an adequate examination. Most surgeons consider inspection and palpation of the ducts sufficient, others open and explore the inside of the ducts in every case. It may be said that the ducts must be explored if there is jaundice, past or present; if, after palpating the ducts, it is thought that a stone is present; or if the ducts are dilated, thickened or inflamed. A fibrosed and contracted gall-bladder is another indication for exploring the ducts, for it is evidence of long-standing infection which must have contaminated them. Finally, if still uncertain, it is of some value to aspirate bile from the duct and examine it in the syringe through transmitted light. If it is clear and golden yellow it is unlikely that stones or cholangitis are present.

(d) Exposure of field of operation

Exposure of the gall-bladder region is aided by the use of a lumbar rest or sand-bag under the lower dorsal spine, and by tilting the table into a 10 to 15 degree reverse Trendelenburg position. The stomach should be pushed over to the left with a large moist pack and the colon, duodenum and intestines are pressed downwards with another pack. These packs should be retracted by the hands of the first assistant. The suspensory ligament is divided and traction made on it so as to elevate the liver. The gall-bladder is grasped by



(a) (b)

FIG. 153.—Cholecystostomy.

one pair of Duval's forceps placed on the fundus and another pair on Hartmann's pouch.

(2) Operations

(a) *Cholecystostomy*

More than usual care must be taken in walling-off the rest of the abdomen with packs and the lesser sac should be protected by a small pad in the foramen of Winslow.

The fluid content of the bladder is removed with a trocar, the bladder is opened and the stones are scooped out. The inside of the gall-bladder is palpated with the left forefinger, and the greatest care taken to see that no stones are left impacted in the cystic duct. A soft rubber tube, ½ an inch in diameter, is fixed in the gall-bladder with double purse-string or mattress sutures (Fig. 153 (a)). Omentum should, if possible, be wrapped round the tube and a piece of rubber tissue drain is placed in Morison's pouch (Fig. 153 (b)).

(b) *Cholecystectomy*

Retrograde cholecystectomy

It is commonly agreed that the safest and easiest method of removing the gall-bladder is from the neck towards the fundus. Retrograde cholecystectomy may sometimes seem to be the easier method but in practice this method is very rarely indicated.



FIG. 154.—Cholecystectomy. Exposure of junction of cystic, hepatic and common bile-ducts.

Emphasis has already been made on the need for clearly exposing and positively identifying the cystic artery and the junction of the cystic duct with the hepatic and common bile-ducts before they are clamped or divided (Fig. 154). The cystic duct should be tied not closer than ¼ inch from its junction with the common duct, and the cystic artery should be divided close to where it reaches the gall-bladder. In removing the gall-bladder from the liver, as wide a cuff of peritoneum as possible should be left on either side, and the two edges should then be sewn together to cover the raw area of the gall-bladder fossa. Suture of a piece of omentum over the stumps of the cystic duct and artery will help to prevent the formation of adhesions involving the duodenum.

Drainage must never be omitted after the standard cholecystectomy operation. A small drain of soft rubber tissue will be sufficient, but it must be retained for at least 3 days in case there is a leakage of bile from accessory bile-ducts unrecognized at the time of operation. To avoid the use of drains, electro-coagulation of the gall-bladder bed is used by some surgeons (Bailey, and Love, 1939; Thorek, 1931). *Drainage*

(c) Choledochostomy

The field of operation is isolated in the same way as for other operations in this region. The common bile-duct is identified by aspirating bile or located by inserting two stay stitches about ½ inch below the insertion of the cystic duct. The duct is opened between the stay stitches and the bile aspirated. The common and hepatic ducts are systematically explored with scoops. Graduated metal or gum-elastic bougies are passed down the duct and through the sphincter of Oddi into the duodenum—no attempt should be made to pass a sound of more than 8 millimetres diameter as it may cause laceration and consequent scarring of the sphincter.

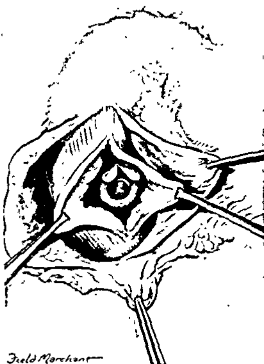


FIG. 155.—Transduodenal choledocholithiasis. Duodenum has been mobilized and opened longitudinally. Stone present at mouth of common duct, which has been slit open.

In every case in which the common bile-duct is opened it should be drained. In most cases a fine tube directed up the hepatic duct will be sufficient but if as in chronic pancreatitis, prolonged drainage is needed, a T tube should be used. The tube should be sutured into the duct with plain catgut. *Drainage*

The operation is completed by removing the gall-bladder. Occasionally choledochostomy rather than excision of the bladder is indicated.

(d) Choledocholithiasis

After the common duct is opened, the stones in it, or in the hepatic ducts, can usually be milked out through the opening. Any stones which do not come out in this way can generally be extracted with a scoop or Desjardin's forceps. Rarely, a stone is impacted at the lower end of the common duct and cannot be milked or otherwise manipulated up to the incision in the duct. In such a case the duodenum should be mobilized by incising the peritoneum on its outer side, and opened by a longitudinal incision (Fig. 155). An incision can then be made into the common duct directly over the stone. The incision

in the anterior wall of the duodenum is sutured transversely and covered with an omental patch.

(*e*) *Cholecysto-gastrostomy and cholecysto-enterostomy*

(i) *Cholecysto-gastrostomy.*—This has been unfavourably criticized on the grounds that it leads to pyloric stenosis and is frequently followed by cholangitis. The first complication can be avoided if the anastomosis is made not less than 1 to 1½ inches from the pylorus. To avoid tension on the suture line the stomach should be fixed to the falciform ligament or to the under-surface of the liver.

(ii) *Cholecysto-enterostomy.*—Anastomosis to the duodenum is more difficult, has a higher mortality than cholecysto-gastrostomy and has nothing to

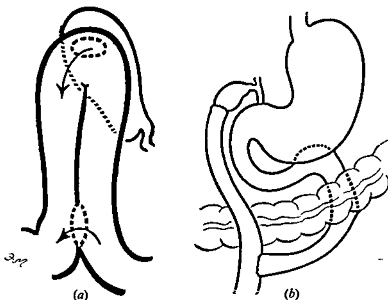


FIG. 156.

recommend it. Cholecysto-jejunostomy is the ideal procedure. A loop of bowel 18 inches from the duodeno-jejunal flexure is carried in front of the colon and anastomosed to the fundus of the gall-bladder; the proximal and distal limbs of the loop are then joined together from 4 to 6 inches below the junction with the gall-bladder (Fig. 156 (a)). Alternatively the anastomosis may be done by the Roux-in-Y method (Fig. 156 (b)).

7. POST-OPERATIVE TREATMENT AND COMPLICATIONS

The post-operative care follows the lines common to all forms of abdominal operations.

Drains

If a drain has been placed down to Morison's pouch it should not be removed too soon; in most cases the fourth day will be soon enough, but if there is any drainage of bile it should be left in a few days longer. Tubes in the common or hepatic ducts will have been sutured into the ducts with catgut—

T tubes

they become loose and can be removed in 8–12 days after operation. If a T tube has been used it can be clamped for an hour on the seventh to eighth day, and this period is gradually extended until the tube remains clamped. If

there is any pain or fever when the tube is clamped, the clamp should be removed and a cholangiograph made, to see if there is any organic obstruction. If the tube remains clamped without causing any symptoms then it can be removed.

(1) Haemorrhage

The best treatment of this erstwhile common complication is prophylactic (*see* p. 254). If post-operative bleeding occurs large doses of vitamin K and transfusions of fresh blood are the best treatment. *Prophylactic treatment*

(2) Hepatic failure

This complication may be suspected if the jaundice deepens, the temperature rises and the patient is restless. Often there is diminution in the urinary secretion, orthopnoea and a rise in the concentration of blood urea.

Treatment of hepatic failure consists in intravenous glucose injections, oxygen therapy to counteract the anoxaemia and blood transfusions to supply haemoglobin for oxygen carrying. If there is a deficiency of chlorides sodium chloride should be given intravenously.

(3) Cholangitis (*see* p. 253)

(4) External biliary fistula

Apart from the rare cases in which external biliary drainage is a necessary surgical procedure, a persistent external biliary fistula is an indication for further operation, as there is almost certainly either a residual stone in, or a stricture of, the bile-ducts.

(5) Stricture of the bile-ducts (*see* p. 249)

(6) Residual stones

No matter how careful the search, a stone may sometimes be missed and may give rise to residual symptoms—pain, jaundice or persistent fistula. The diagnosis from primary functional conditions—biliary dyskinesia—may be very hard. Observation during and just after an attack of pain will often settle the diagnosis; a rise in the serum bilirubin, a change from indirect to direct reaction or a rise in the sedimentation rate suggests the presence of stones. Fever, rigors or chills are proof of organic obstruction.

If the symptoms persist re-operation will be called for.

(7) Duodenal adhesions

Angulation of the duodenum as a result of adhesions to the raw area in the region of the gall-bladder notch may give rise to symptoms suggesting biliary colic. The diagnosis can usually be made by careful radiological examination.

(8) Biliary dyskinesia (*see* p. 253)

BIBLIOGRAPHY AND REFERENCES

Bailey, H., and Love, R. J. McN. (1939). *Brit. med. J.*, **2**, 869.
Clark, J. H. (1932). *Int. Clin.*, **1**, 78.
Flint, E. R. (1923). *Brit. J. Surg.*, **10**, 509.
Graham, E. A., and Mackey, W. A. (1934). *J. Amer. med. Ass.*, **103**, 1497.
Graham, H. F., and Hoefle, M. E. (1938). *Ann. Surg.*, **108**, 874.

Gray, T. C., and Halton, J. (1946). *Proc. R. Soc. Med.*, **39**, 400.
Gross, R. E. (1933). *J. Pediat.*, **3**, 730.
Hunt, V. C., and Budd, J. W. (1935). *Surg. Gynec. Obstet.*, **61**, 651.
Illingworth, C. F. W. (1929). *Brit. J. Surg.*, **17**, 203.
— (1935). *Ibid.*, **23**, 4.
— (1936). *Edinb. med. J.*, **43**, 481.
Ladd, W. E. (1935). *Ann. Surg.*, **102**, 742.
Maingot, R. (1940). *Abdominal Operations*, Vol. 1. New York and London; Appleton-Century Co.
Mayo, W. J. (1911). *J. Amer. med. Ass.*, **56**, 1021.
Thorek, M. (1931). (Personal communication.) Quoted by Maingot, R. H. (1940) in *Abdominal Operations*, Vol. 1, p. 762.
Walters, W., and Snell, A. M. (1940). *Diseases of the Gall Bladder and Bile Ducts.* Philadelphia; Saunders.
Walton, A. J. (1915). *Surg. Gynec. Obstet.*, **21**, 269.

[References to other titles are given under Gall-bladder and Bile Passages in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 477.]

GANGLION

By R. M. HANDFIELD-JONES, M.C., M.S., F.R.C.S.
Surgeon, St. Mary's Hospital, London

1. DEFINITION

162.] A ganglion is an encapsuled cystic swelling arising from the sub-synovial connective tissues of joints and, in very rare instances, from those of tendon sheaths. It will be appreciated that it bears no relationship to a ganglion of nerve cells; furthermore it has no pathological similarity to the so-called "compound palmar ganglion", which is a tuberculous teno-synovitis of the synovial bursae in front of the wrist joint and which will not be described here.

2. ANATOMY

The joints associated with ganglion formation in order of frequency are:

Joints

(1) The extensor aspect of the wrist and carpal joints, where the swelling may come to the surface at any point.

(2) The flexor aspect of the wrist joint, where it presents either in close proximity to the radial artery or immediately lateral to the flexor carpi ulnaris tendon.

(3) The lateral aspect of the ankle joint usually behind the external malleolus and in relation to the peroneal tendons.

(4) The tarsal and tarso-metatarsal joints upon their dorsal aspect.

(5) The knee joint, especially in children. Although chronic serous bursitis of the semimembranosus bursa unquestionably causes a swelling in the popliteal space (*see* Bursae, Vol. 2, p. 534), nevertheless a great many examples of so-called bursitis are found on removal to be typical ganglia. This point of clinical pathology deserves more widespread attention.

(6) *Less commonly the interphalangeal joints of the fingers upon their* extensor aspect may be the site of a ganglion, whilst others, more rarely still, are the acromio-clavicular and sterno-clavicular joints.

Tendon sheaths

The tendon sheaths which may be the origin of a ganglion are:

(1) The digital sheaths of the index, middle and ring fingers. The tumour forms at the apex of the palmar diverticulum of these sheaths, and always remains small, very tense and exquisitely tender.

(2) Very rarely the ganglion behind the external malleolus is proved to be arising from the peroneal tendon sheaths.

3. PATHOLOGY

In spite of its frequent occurrence the true nature of a ganglion has never been determined. To the naked eye it presents a smooth, regular spherical capsule

growing from a broad pedicle attached to the capsule of the joint. On opening it a thick jelly-like fluid seeps out. It is colourless and sticky. Its microscopic appearance is that of a true myxoma with a gelatinous matrix containing widely scattered spider-cells bearing an exact resemblance to Wharton's jelly of the umbilical cord. The view probably gaining most acceptance today is that a ganglion is a true benign neoplasm, but there is much to be said for the feeling that the clinical facts rather point to a degenerative process based upon a mild traumatic origin. At all events in most patients a history of slight strain is usually obtainable.

4. CLINICAL SIGNS

Pain and swelling

These are pain and swelling. Dull, aching pain occurs in a strictly localized area related to a joint before any swelling is seen and may be quite severe. It continues during the earlier stages of tumour formation, but as soon as tension disappears and fluctuation becomes perceptible all pain ceases. In untreated cases the ganglion tends to vary considerably in size; indeed at times no swelling can be detected. From my personal experience I have noticed that recrudescence almost always follows upon violent use of the wrist, for example after playing squash rackets or tennis.

In general a ganglion grows to moderate size not exceeding 1½ inches in diameter. In the earlier stages ganglia are spherical, and so tense as to appear almost bony hard; later they often become slightly lobulated, being soft and fluctuant. At the base of the fingers beneath the palmar pad over the metacarpal head they invariably remain small—never reaching the size of a pea—tense and tender. Interference with function is rarely a marked feature of these tumours. At the ankle they will probably interfere with the comfortable wear of boots and shoes; behind the knee they may give a transient sense of insecurity; those at the wrist may do likewise. The most disabling ganglion is the one at the base of the fingers, for the slightest pressure will cause such pain as to reduce the capacity of the hand to a minimum.

5. TREATMENT

There is often no real indication for treatment, but if they interfere with function or are unsightly they can be dealt with by one of two methods. In olden days it was traditionally reported that a blow with the family Bible caused rupture and dispersal of the contents with a fair chance (about 50 per cent) of permanent cure. In place of such gross trauma today the capsule may be incised subcutaneously by a fine sharp-pointed tenotome, the contents expressed by pressure, and a firm bandage applied for 3 days. A small weal is raised in the skin with 2 per cent Novocain for the introduction of the tenotome. This is the method of choice for palmar ganglia at the base of the finger.

Incision

Excision

The second method is excision which must be done under general anaesthesia and in a bloodless field. The notorious tendency of a ganglion to recur after operation is due to the erroneous but still widespread teaching that it arises from a tendon sheath with the result that the dissection is not carried sufficiently deep. The whole sac *must* be removed, and this entails tracing it past the tendons and down to the underlying joint capsule, a small circular area of which will usually be removed.

Upon the dorsum of the wrist a vertical cut in the long axis of the limb is to be avoided because of the tendency to keloid formation in the scar—a most unsightly blemish in an ever-visible area. An incision should be made over the prominence of the swelling in a skin crease passing across the back of the wrist. Undoubtedly this tends to make access a little difficult but the handicap has to be faced. *Incision over the wrist*

In front of the wrist the proximity of the ganglion to either the radial artery or the ulnar artery and nerve makes a vertical incision essential, and great care must be taken to define and protect these structures.

In the peroneal region an incision is made over the swelling in the line of the tendons, and a ganglion on the inner aspect of the popliteal fossa is best approached by a transverse incision to avoid keloid formation in the scar.

A description of treatment cannot end without mention of injection of sclerosing fluids. No words can be too strong to condemn this practice. The connexion of a ganglion with a joint or even with a tendon sheath should be enough to banish sclerosing fluids from this small branch of surgery. The *personal experience of a distinguished surgeon attached to the staff of a great* teaching hospital should bring this lesson home to us all. To test the method he aspirated and injected a ganglion upon the dorsum of his own wrist. His description of the agony which he suffered for 48 hours and his inability to work for 10 days should be a sufficient warning as to the danger of this method of treatment. *Injection of sclerosing fluids condemned*

[References to other titles are given under Ganglion in the Index Volume.]

GANGOSA

See Tropical Disease and Surgery

GANGRENE, CLOSTRIDIAL (GAS GANGRENE)

BY F. A. R. STAMMERS, C.B.E., CH.M., F.R.C.S.
PROFESSOR OF SURGERY, UNIVERSITY OF BIRMINGHAM; SURGEON, BIRMINGHAM UNITED HOSPITAL

1. DEFINITION

163.] Gas gangrene is an acute, fulminating, spreading gangrene sometimes associated with gas formation, resulting from infection of traumatized and devitalized tissues—preponderatingly muscle—by anaerobic, spore-bearing bacilli of the clostridium group, and characterized by profound toxaemia.

2. AETIOLOGY

A disease of war

The disease is fortunately rare in civilian practice. Almost nothing was known about it until World War I, yet so excellent were the observations of such surgeons as Gray and Wallace, and of such pathologists as Shaw-Dunn and McNee that the best and most vivid account of it is to be found in the Official History of the War (1914–18): Medical Services (Wallace, 1922). Our more recent and more prolonged, yet less intense, experience of 1939–45 has confirmed what was written then, and little more than certain details of bacteriology has since been added to our knowledge. In war the incidence may be as high as 5 per cent of all wounded, with a mortality of 50 per cent, but as experience is gained this may be reduced to 1 per cent and 20 per cent respectively.

Incidence

A disease of circumstances

The disease is essentially one of circumstances, for it is the conditions under which a man is wounded and under which he has to be treated that determine whether or not gas gangrene is likely to develop. Fighting over highly cultivated soil in cold, wet weather when the soldier is wearing many thicknesses of clothing soaked in liquid mud, and in terrain where communications are difficult so that delay in surgical treatment is inevitable, encourages gas

gangrene. Fascia, blood clot and brain may all be affected, but crushed, lacerated and devascularized muscle is predominantly the tissue favoured by the clostridia, and wounds in large muscular areas such as calf, thigh and buttock, caused by ragged pieces of metal such as fragments of shell, bomb or mortar, are especially liable to develop gas gangrene unless correct treatment is promptly available. *Importance of devitalized muscle*

Damage to blood supply is the all-important factor, and anything that embarrasses the local supply directly—as for example tourniquets, tight bandaging or badly applied splints—or the general circulation directly or indirectly, such as injury of important arteries, severe haemorrhage, exposure, starvation, dehydration, long journeys over bumpy roads, pain, or the continued absorption of the products of muscle damage, renders the victim more susceptible. *Blood supply*

The responsible organisms are much more often implanted by indriven pieces of clothing or equipment than by the metallic fragment itself, and bitter experience has repeatedly shown that plugging of wounds by gauze, or stitching of wounds before it is certain that infection has been successfully circumvented, add to the incidence of this dread disease. *Indriven foreign matter*

3. SURGICAL ANATOMY

Being essentially a disease of dead or injured muscle the infection closely follows those parts deprived of blood supply. The blood-vessels of muscles run within the bellies parallel to the fibres, and this explains why the infection tends to spread longitudinally. Several muscles, such as the gracilis, depend for their nutrition upon a single main artery, and this explains the occasional finding of a single infected muscle lying amongst healthy ones; and the fact that many of the arterioles are end arteries, so that inosculation between adjacent segments of muscle is poor, explains why there is sometimes an abrupt transition from normal to infected muscle. *Blood-vessels*

When gas forms it is conducted to the subcutaneous tissues along the vessels, especially the perforating branches, and also by the intermuscular septa.

4. PATHOLOGY

(1) Morbid anatomy

Almost always, affected muscle fails to bleed or to contract under the mechanical stimulus of scissors, knife or forceps, but this is more a characteristic of devascularized muscle than of infected muscle. *Loss of contractibility*

The amount of muscle infected varies from the purely local solitary one or two muscles already mentioned to a complete segment such as buttock or thigh—then known as massive gangrene. Most commonly, the disrupted parts of several muscles are affected, the lesion ceasing comparatively abruptly at different levels in the different muscle bellies according to the extent of vascular damage in each.

Various colour changes are to be observed. The muscle may merely look bruised or plum-coloured; it may be salmon-pink, the so-called "red death"; it may be greenish-black, rather like dried faeces; it may be yellow and friable; or in very advanced stages it may be black and diffluent. The general tendency is towards dryness, any such discharge as there is being minimal and in the *Colour changes*

form of evil-smelling serum which may or may not contain bubbles of gas. The surrounding structures vary from normal to tissues blown up with yellowish or bloody oedema, the result of haemolysis. The skin is affected late, and even when of normal appearance it may overlie massive gangrene. As tension increases the skin becomes preternaturally pale, but later on extravasation of lysed blood leads to mottling. With gas-forming organisms it becomes tympanitic.

In fatal cases gas may be found in the heart muscle, liver and brain, and there is an *intense necrosis of kidney and liver cells.*

(2) Bacteriology

A wound sustained under the circumstances described is from the moment of infliction heavily contaminated with a large mixture of organisms, but the principal ones responsible for the clinical entity under discussion are *Clostridium welchii*, *Clostridium septicum* (*Vibrion septique*) and *Clostridium oedematiens*. These are anaerobic spore-bearing bacilli, several species usually occurring together, and by far the most important of these is *Cl. welchii*, this being true of both the first and second World Wars.

Clostridium welchii

Significance of presence of clostridia in wounds

The mere presence of clostridia in a wound does not spell gas gangrene, and many optimistic statistics have resulted from this error. Indeed, at Base hospitals it was not uncommon, during the era of routine delayed suture of all wounds, to find at the first dressing clostridia in a solitary slough or blood clot lying in an otherwise clean wound. Likewise, in "Forward" areas, where the key to the solution of the gas gangrene problem really lies, the presence of clostridia within a wound does not mean that clinical gas gangrene is present.

Comparison of contamination with infection

These facts merely emphasize the crucial difference between contamination and infection: in both wars it has been shown repeatedly that the organisms of a contaminated wound remain relatively superficial for about the first 8–12 hours, after which they invade deeper tissue. This is a fundamental fact of all open trauma, but particularly so of war wounds. The most important factor is the toxin which these clostridia produce, and one of the outstanding features in a fulminating case is the profound toxaemia. During World War II most of the newer laboratory work, both in the field and at home, was done by Evans (1943a and b) and by MacLennan (1946) and Marjorie Macfarlane (1946), and experiments were carried out with numerous sub-strains of *Cl. welchii*, each producing different toxins or different combinations of such toxins.

Clostridial toxaemia

Necrotizing effect of toxins

The oustanding action of these toxins is the intense necrosis they produce, and in fatal cases this effect is seen in vital organs such as the liver and kidneys. Macfarlane and MacLennan (1945) have made the interesting suggestion that the resulting products of muscle necrosis may be the same as those absorbed into the general circulation from extensive laceration of muscle alone: this would account for the low blood-pressure and oliguria or anuria sometimes observed.

Effect on blood-pressure

(3) Immunology

Antitoxic sera containing a mixture of *Cl. welchii*, *Cl. septicum* and *Cl. oedematiens* antitoxins are available. Unfortunately, the products of different manufacturers contained *entirely different proportions*, but during the last

Proportions of antitoxins

year of World War II more refined serum became the standard and contained the following mixture:

Cl. welchii	9,000 units of antitoxin
Cl. septicum	4,500 units of antitoxin
Cl. oedematiens	9,000 units of antitoxin

This followed the insistence by MacLennan that for prophylactic purposes the minimal dose of *Cl. welchii* antitoxin should be 9,000 units, and that in the days when there were about half a dozen different brands the dose of any brand should be that quantity containing not less than 9,000 units of *Cl. welchii* antitoxin. For therapeusis three times this quantity is given.

Assessment of the value of antitoxins

It is almost impossible to assess the efficacy of any particular treatment under conditions of war, and there are some who believe that too much credit has been given to antitoxin. Certain it was that other advances in treatment developed at the same time, such as more readily available blood, the sulphonamides and penicillin, and in an infection carrying so grave a prognosis few had the courage to omit any one of these measures.

5. CLINICAL PICTURE

Modes of onset

Fulminating case

The infection usually declares itself 24 to 48 hours after wounding. The onset is sudden and the march of symptoms rapid. Sometimes it develops much earlier, and a man may be brought in with fully established gas gangrene only 4 or 5 hours after wounding. This usually happens in a major muscle wound, and I have seen three such cases where the whole of the buttock muscles on one or other side were affected. On the other hand, it may develop as late as the fifth day (and this in spite of excision in "Forward" areas), and it is these cases that are seen at the Base. The delayed onset does not make it any the less lethal, for the mortality has been reported to be as high as 50 per cent. However, during the last 12 months of the Italian campaign, as the result of a policy of more thorough excision of wounds, both the incidence and mortality were reduced, and so, too, the number of cases of delayed onset.

The typical case

Toxaemia

In a typical case developing under one's eyes, usually before but occasionally after surgical toilet, the wounded man's condition changes within a few hours, and the outstanding feature is the rapidly progressive toxaemia. From a relatively satisfactory patient, he becomes pale or livid, anxious, afraid or euphoric, but mentally alert, sometimes absolutely unaware of the seriousness of his illness. The temperature may be slightly raised but is often subnormal, the pulse rises and becomes feeble, dicrotic and running, and the blood-pressure is low. The limbs are blue, cold and clammy. The whole picture is one of peripheral vascular failure and mimics exactly a case of severe muscle injury suffering from prolonged (say 6 hours) absorption of its products, or a case of acute hypoproteinaemia, or a patient dying of general peritonitis, and it is seen most characteristically in the man who has been lying out in the open for many hours, and who is suffering both from absorption of the products of damaged muscle and from the specific toxaemia of gas gangrene. Such a patient arrives utterly prostrated and nothing but the most prompt and vigorous surgical intervention is likely to save him. In addition to these general features more local symptoms develop. The man often complains of the onset of pain in a formerly comfortable and satisfactorily splinted limb, though it should be recorded that during the last 12 months of World War II a number

Pain

of surgeons thought that this symptom was becoming less common. On inspection, the affected part looks swollen and pale, the exposed muscle may present any of the appearances described under morbid anatomy, and there is a curious fusty smell. Later on colour changes may develop in the skin. Gas may or may not be present. Rarely the affected part is tympanitic, but more usually the sign of gas is surgical emphysema, which in its earliest stage is more readily detected by varying pressures with the stethoscope. Gas can be demonstrated by radiography but this may not be available. The really important points are the rising pulse rate, the mental change and, often, the onset of pain.

Gas

6. DIFFERENTIAL DIAGNOSIS

To the experienced Army surgeon in an environment of war there is little difficulty in diagnosing the condition. Unfortunately, owing to the rarity of clostridial infection in civilian practice, it takes some time in total war before medical officers and surgeons become familiar with it. During this early phase many are misled by the odour of a wound, and unnecessary amputations have unquestionably been performed because of this. It should be realized that many wounds heavily contaminated with a mixture of organisms, and in which there has been inevitable delay in applying treatment, have a most evil smell, but this does not necessarily mean clostridial infection, and in the absence of toxaemia the diagnosis should not be made. Another error is due to the misinterpretation of air in the tissues. This may happen when a small sharp fragment of metal, entering the body through a small skin wound, cuts across muscle fibres which spring apart and, like the piston of a syringe, suck air into the space produced. This air is soon disseminated and on examination crepitus is found. In the absence of signs of toxaemia this should not be mistaken for the gas of clostridial infection.

The significance of odour

The significance of gas

Prostration is so prominent a feature of both gas gangrene and of the result of absorption of the products of muscle damage that doubt may sometimes arise, but the absence of the characteristic local signs and of the typical mental alertness are points in favour of the less serious condition. In fact, it may not be possible in these cases to be quite sure until operative exposure of the muscles takes place.

The products of muscle damage

Finally, the condition of streptococcal myositis sometimes causes difficulty in diagnosis, but until the late stages there is not the prostration, the signs of peripheral vascular failure or the clear mentality, and the temperature is higher.

Streptococcal myositis

7. PROGNOSIS

The prognosis of the established infection is bad, and during both World Wars incidence at different phases amounted to 5 per cent and mortality to 50 per cent or over. These figures, however, are vitiated by the mistaken diagnoses that inevitably occur whilst medical officers and surgeons are learning their jobs. It cannot be stressed too strongly that war surgery is just as much a speciality as orthopaedic surgery (in its old definition) and can only be mastered by long, bitter, practical experience. Prognosis depends upon the experience of the medical services, and the problem concerns the Administration as much as it does the technicians, for time being so important a factor, the deployment of surgical units and transfusion units is of vital

Prognosis depends upon experience of the whole organization

importance. It was a significant fact that the incidence and mortality of the disease always rose with the change from desert warfare to fighting over cultivated country, or when medical officers and surgeons new to battle casualties first appeared in an area of activity.

By the year 1918 the incidence in Flanders had fallen to 1 per cent and the mortality to 22 per cent, and this without sulphonamides or penicillin. It is doubtful whether the figures for 1939–45 are yet available, but the conditions in the Desert, Italy, Northern Europe and Burma were so different that there must be great variation. Certain it is, however, that everywhere these figures improved as the campaign progressed, and towards the end my impression as Consultant to the Allied Armies in the "Forward" areas of Italy was that the incidence had been reduced to less than ½ per cent, and the mortality to 10–20 per cent. The additional weapon of penicillin has reduced this hard core still further, but it was only available in adequate quantities during the last 12 months of World War II. *Steadily improving results*

8. TREATMENT

Although one must be prepared to deal with the established case, the essential treatment of gas gangrene is prophylactic from the moment of wounding—every wound of muscle received under circumstances akin to those described is a potential case of clostridial infection.

(1) Preliminary prophylaxis

In warfare it is assumed that the man himself or one of his comrades will apply a first field dressing, and that when he is bad enough to need carrying the stretcher bearers will deal with fractured limbs according to the teaching of the R.A.M.C. manuals—immobilization, correct application of the Thomas splint when such is necessary, bandaging that is not too tight, strict adherence to the rules regarding the use of the tourniquet when injury to a main artery makes one necessary. The patient must be kept warm and be taken with all dispatch to the nearest dressing station. The point that must never be forgotten is that in the presence of extensive laceration of muscle the most urgent need is surgery, and therefore that not too much time should be spent on resuscitation. Better far to administer morphine, to give a pint of glucose-saline intravenously quickly, and then to send him with an in-ambulance drip to the nearest surgical centre. Generally speaking it is bad practice to spend more than an hour on resuscitation forward of the surgical centre; the urgent need is to excise the damaged muscles, for until this is achieved the blood-pressure will not be restored permanently, nor will the risk of gas gangrene be eliminated. General opinion also urges that antitoxin be given at the earliest possible moment—sufficient to contain 9,000 units of *Cl. welchii* antitoxin; and in military work in which difficult communications threaten to lead to delay, stocks should be held at regimental aid posts. On such occasions the Administration should send forward to a field ambulance a mobile surgical unit to deal with the life-threatening wounds—abdomens, open pneumothoraces, major muscle wounds. *First aid* *Wounds of muscle* *Antitoxin*

(2) Surgical prophylaxis

This means the proper surgical treatment of all wounds, but especially of those involving muscle, and the subject is dealt with in fuller detail elsewhere.

The fundamental principles are as follows:

Fundamental wound treatment

Only bruised or crushed edges of skin are excised. The skin wound is sufficiently extended by incision to allow of the insertion of retractors to the full depth of the wound so that adequate inspection can be carried out. Dirty fat and fascia, or any tags of either, are removed. All muscle that does not contract or bleed when cut should be removed. Search must be made for any pieces of indriven clothing or equipment, and these and any readily accessible metallic fragment should be removed. Any nooks or crannies in which pockets of pus might collect are laid open. Incisions, both transverse and longitudinal, into the deep fascia are made as a prophylactic decompressive measure. A heavy frosting of penicillin is applied, by insufflation for preference. Packing and stitches are forbidden. A dry dressing is applied and, when a limb is involved, carefully splinted.

Delayed suture

No meddlesome inspection of dressings

The general policy for all cases during the later stages of the war was to evacuate them within 3 or 4 days to a Base or Lines-of-Communication hospital where they could be held, and to perform a delayed suture about the fifth day after the first operation. The wound was not inspected between these two occasions unless the patient complained of pain or unless there was evidence of a developing toxaemia. Major muscle wounds in which blood-pressure has been depressed for many hours should be held in "Forward" areas for 3 or 4 days prior to evacuation, since experience shows that these cases are in a state of metabolic instability and that movement tends to precipitate a relapse.

(3) The established case

Bold surgery

Bold surgery, blood, penicillin and antitoxin are imperative, but as already said, too much time should not be spent on resuscitation. These patients are always seriously short of fluids and Shock Research Teams during World War II showed that blood loss had usually been far greater than was imagined. It has already been pointed out that the condition of the patient is due to the toxin of the clostridia plus the toxin absorbed from damaged muscle. Experience shows that after about 3 hours the blood-pressure does not respond to intravenous fluids until the damaged muscle has been removed.

Blood transfusion

The best plan therefore is to give 2 pints of blood rapidly (say in ½ an hour, using positive pressure if need be to accelerate intake) and then to take the patient to the theatre with a third pint of blood or glucose-saline still running.

Damaged muscle

All affected muscle must be excised. This is best done by removing the complete muscle belly from origin to insertion, though in large muscles like the adductor magnus it may only be necessary to remove one part of it. All discoloured muscle, and any that does not contract or bleed under the influence of the knife or scissors, should be removed. Sometimes enormous amounts have to be excised—on three occasions I have seen the entire group of gluteal muscles taken away because of gas gangrene, two of the cases recovering—and a limb may be so disorganized as to require immediate amputation, but the amputation rate becomes much lower as the prophylactic surgery improves in quality.

Antitoxin

At the end of the operation 100,000 units of antitoxin are given intravenously. The intravenous fluids are continued up to 4 or 5 days at the rate of about 5 pints each day, one pint being plasma to combat hypoproteinaemia

and blood should be given according to haemoglobin estimations. Parenteral penicillin is given, 15,000 units 3-hourly for 5 days, but this dosage will probably be revised with increasing experience. *Penicillin*

9. SUMMARY

From the foregoing it will be seen that the incidence of clostridial infection, mainly in war but occasionally in civilian practice, varies inversely as the following policy can be implemented.

1. If a wound needs surgical intervention at all it needs it at the earliest possible moment. Surgical centres should be so deployed that under all circumstances there is a reasonable chance that every major case can receive surgical treatment within 2–6 hours of wounding, and all the remaining cases within 12 hours. *The fundamentals*

2. All wounds of buttock, thigh, calf and axillary regions should be given full prophylactic doses of gas gangrene antitoxin (containing 9,000 units of *Cl. welchii* antitoxin) at the earliest possible moment. In warfare this was usually at the advanced dressing station, but in isolated districts, such as in the mountains north of Florence during the winter of 1944–45, stocks were distributed to the regimental aid posts.

3. All major muscle wounds should be regarded as top-priority cases.

4. In view of the fact that the most urgent need is to excise the damaged muscle, as also because of the effect on blood-pressure of the absorbed products of damaged muscles, it is important not to spend too much time on resuscitation—not more than an hour. Any further need for fluids can be satisfied by continuing the intravenous fluids in the ambulance.

5. The technique of wound toilet must be thorough, bold and purposeful, as described.

10. RESULTS

We know from World War I that the incidence of gas gangrene can be cut down to 1 per cent and the mortality to 22 per cent without penicillin. During the last offensive in Italy in 1945, almost the only cases of clostridial infection occurring were in German prisoners whose collection was delayed. Penicillin must be given some credit for this, but the most important single factor was good early surgery.

BIBLIOGRAPHY AND REFERENCES

Evans, D. G. (1943a). *Brit. J. exp. Path.*, **24**, 81.
— (1943b). *J. Path. Bact.*, **55**, 427.
MacFarlane, Marjorie (1946). *Proc. R. Soc. Med.*, 39, 294.
MacFarlane, R. G., and MacLennan, J. D. (1945). *Lancet*, **2**, 328.
MacLennan, J. D. (1946). *Proc. R. Soc. Med.*, 39, 293.
— and MacFarlane, R. G. (1945). *Lancet*, **2**, 301.
Stammers, F. A. R. (1945). *Memoranda to Allied Armies in Italy, Reports to War Office.* (Unpublished Communication.)
— (1946). *Proc. R. Soc. Med.*, 39, 291.
Wallace, C. S. (1922). In *History of the Great War based on Official Documents. Medical Services: Surgery of the War*, Vol. I, p. 134. London; H.M. Stationery Office.

[References to other titles are given under Gangrene, Clostridial (Gas Gangrene) in the Index Volume.]

GASTRO-COLIC FISTULA

SIR HENEAGE OGILVIE, K.B.E., M.D., M.CH., F.R.C.S., F.R.C.S.(C.)
HON.F.R.A.C.S., HON.F.A.C.S.
SURGEON, GUY'S HOSPITAL; SURGEON, ROYAL MASONIC HOSPITAL, LONDON

1. DEFINITION

164.] A gastro-colic fistula is a communication between the stomach and the colon, from whatever cause. The term includes gastro-jejuno-colic fistula, which is the most important and the only common variety.

2. AETIOLOGY AND MORBID ANATOMY

The greater curvature of the stomach and the transverse colon lie in close proximity. Any destructive lesion of one could invade the other, but in fact this happens very rarely. Gastric ulcer does not involve the greater curvature or erode into the colon. A carcinoma arising in the stomach may invade the colon and form a fistula and, similarly, a fistula may result from extension of a colonic growth to the stomach, but this complication is almost unknown in gastric cancer and rare in colonic cancer. Ulcerative colitis is prone to form fistulous tracks, and these occasionally open into the stomach (Fig. 157). However, the only common fistula is the gastro-jejuno-colic fistula following gastro-enterostomy.

Gastro-enterostomy

The practice of performing gastro-enterostomy for the relief of the symptoms of duodenal ulcer even when there is no stenosis was prevalent in the 1920's and 1930's, and is not yet extinct. Hyperacidity, which is a characteristic feature of the duodenal ulcer diathesis, persists after gastro-enterostomy and even after gastrectomy which is not really radical, and this high acid secretion is even less well tolerated by a surface not designed to receive it and unprotected by any proximal sphincter, than it is by the duodenum. Jejunal ulcer is thus a frequent sequel of gastric surgery, occurring in at least 20 per cent of

all cases submitted to gastro-enterostomy and in an appreciable proportion of those on whom gastrectomy has been performed for non-stenosing duodenal ulcer with a short history (Ogilvie, 1935). Mage (1942), analysing 41 cases of gastro-jejuno-colic ulceration following partial gastrectomy, found no case in which complete achlorhydria had been obtained. In 40 of these cases the operation had been performed for duodenal ulcer, in one for gastric ulcer.

Gastro-jejunal ulceration

Gastro-jejunal ulceration starts at the distal end of the stoma, or more commonly in the jejunum just beyond it, involving the stomach edge secondarily. The ulcerative process, as it continues, destroys all coats of the viscera and extends beyond them into adjacent tissues. In the common retro-colic anastomosis the ulcer first involves the mesocolon between the stoma and the bowel, then it reaches the wall of the transverse colon whose mesenteric aspect forms its base, and finally it penetrates into the lumen.



FIG. 157.—Gastro-colic fistula following ulcerative colitis. Barium enema. (*By courtesy of Dr. Rohan Williams.*)

According to Hurst and Stewart (1929), 10 per cent of jejunal ulcers go on to fistulate: they state that the commonest fistula is jejuno-colic, the next gastro-colic, and the least common gastro-jejuno-colic, but the distinction is unimportant.

3. CLINICAL PICTURE

The characteristic features of gastro-colic fistula are:

(1) The belching of foul, faecal-smelling gas, and less often the vomiting of offensive, and occasionally of faecal material.

(2) Diarrhoea, characterized by its time relation to meals, and by the appearance of undigested food in acid stools.

(3) Loss of weight.

When a growth precedes the fistula, progressive ill health, anorexia or wind pains may occur, though carcinoma of the stomach and of the transverse colon may both be remarkably silent. Ulcerative colitis gives a long and characteristic history.

In most cases the fistula follows on peptic ulceration, and in such cases there has been, almost without exception, a previous operation, usually gastro-enterostomy but occasionally gastrectomy. The symptoms of recurrent ulceration may start at any time from 2 months to 20 years after the operation; in Hurst and Stewart's series the average interval was 5 to 6 years, in Mage's, 2 years. Stomal ulceration gives a clinical picture similar to that of duodenal ulcer, but the pain is apt to come on sooner after meals, it is felt below or level with the umbilicus and to the left of the midline, and it is less easily relieved by food or alkalis.

Stomal ulceration

With perforation into the colon the pain nearly always disappears and the patient feels better, but the foul eructations and diarrhoea distress him and he loses weight rapidly. Eventually he becomes extremely emaciated, and develops the anaemia and hypoproteinaemia characteristic of a nutritional deficiency.

4. SPECIAL AIDS TO DIAGNOSIS

Unless the fistulous track is long or narrow, a communication between the stomach and colon can usually be diagnosed without difficulty on clinical grounds. Confirmation is obtained by radiography. It is seldom possible to demonstrate a fistula by a barium meal, though the opening may be a large one, but a barium enema will readily show the communication (Fig. 158). The fistula may be seen by gastroscopy if it opens into the stomach or the edge of the stoma (Plate II), but one leading into the jejunum will usually be "round the corner" and out of the range of vision.



FIG. 158.—Gastro-colic fistula following peptic ulcer. Barium enema. (*By courtesy of Dr. Rohan Williams.*)

5. DIFFERENTIAL DIAGNOSIS

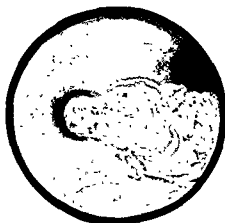
This seldom presents any difficulty. The belching of foul gas is occasionally a symptom of ulcerating carcinoma of the pylorus, and should such a carcinoma form a fistula with the colon the complication might not be recognized at once; the diagnosis would, in any case, be of academic importance only. Rare forms of diarrhoea, with the passage of undigested food and often accompanied by mental disturbance, are associated with deficiencies of the nicotinic acid fraction of the vitamin B complex. Lunatics and hysterical patients occasionally swallow and regurgitate their faeces. In any case of doubt the presence or absence of a fistula can readily be demonstrated by a barium enema.

6. PROGNOSIS

The prognosis in gastro-colic fistula is always grave. If the cause is cancer of the stomach it is hopeless, if cancer of the colon, the prognosis is that of the particular colonic growth, which may be quite a localized one without metastases. In the common type following gastro-jejunal ulceration, the outlook is coloured by the known ulcer tendency of the patient, his state of inanition, and the formidable nature of the operation that is required. If the previous operation has been a gastro-jejunostomy, the opportunity for curative surgery remains, but if the gastro-colic fistula follows gastrectomy the difficulty of the operation and the chances of fresh ulceration are considerably increased.



(*a*)



(*b*)

To show quiescent fistula (*a*) and fistula in action (*b*). The angle of view is a little different in the two: in (*b*) faecal matter is erupting from the fistula and flowing towards the efferent jejunal lumen on the right border of the picture.

PLATE II

7. INDICATIONS FOR SURGICAL TREATMENT

The most important observation under this heading is the Hibernianism that the surgical treatment of gastro-colic fistula is most successful when there is no fistula. The great increase in risk which supervenes when a stomal ulcer perforates into the colon should lead to a much more radical outlook on the part of physicians and surgeons towards gastro-jejunal ulceration that does not yield to medical treatment. If the symptoms persist, an early operation, replacing gastro-enterostomy by gastrectomy, is the only road to safety. When any warning is given, either in a history of colonic or wind pains, or in an alteration of the bowel habit coincident with an increase in ulcer symptoms, or in the demonstration by radiography of an ulcer crater abutting on the colonic wall, that perforation is imminent, operation should be undertaken without delay. Once a fistula has formed the indications for early operation are absolute, unless the cause lies in a gastric carcinoma.

8. PRE-OPERATIVE MANAGEMENT

A starved and dehydrated patient must be prepared as well as possible for an operation of considerable magnitude and no little risk. Much of the preparation must necessarily be done by intravenous therapy, since by no other route can adequate absorption be guaranteed, and it must be done quickly, since the patient is losing ground all the time. No more than a week should usually intervene between the decision to operate and the operation. *Intravenous therapy*

In general, the blood chemistry must be investigated and the deficiencies must be made good. This involves the co-operation of a first-class laboratory, and the care of patients with gastro-colic fistula should be undertaken only where such facilities are available. Estimations of total circulating fluids and fluid reserves, and of haemoglobin proteins and chlorides in the blood, are needed before and during replacement. Repeated transfusions, preferably of fresh whole blood, are required. Plasma and serum transfusions can be used to replace proteins, and may be given alternately with whole blood, particularly if the haemoglobin level is raised fairly easily, but the estimation of the requirements of such patients is by no means simple, since haemoconcentration is likely to be present owing to the rapid dehydration that occurs. If the plasma chlorides cannot be estimated, it is wise to assume a loss and to give a pint or more of normal saline intravenously each day, till chlorides appear in the urine. Fluids should be given in quantities that will produce a urinary output of at least 1,000 cubic centimetres daily. Vitamins B and C should usually be given by injection in large doses, B, as Betaxan intramuscularly, up to 50 milligrams daily, for a week or so before operation, and C, in doses as large as 500 milligrams intravenously. Vitamin B assists the patient to use the glucose which is being given intravenously, and C promotes tissue repair. *Vitamins*

Succinylsulphathiazole, 18 to 24 grammes daily, should be given by mouth for 5 to 6 days before operation to sterilize the colon. *Sulphonamides*

9. OPERATIVE TECHNIQUE

There can be few operations in surgery more formidable than those for the repair of a gastro-colic fistula. The surgeon is faced with an ill patient, an operative field where anatomical landmarks are distorted by previous surgery

and obliterated by adhesions, and an operation whose broad outlines only can be planned beforehand. An intravenous drip should be running, and a suction tube passed through the nostril into the stomach before the operation starts. Every detail of lighting, instruments and assistance that can help should be available. The anaesthetic should be local with splanchnic plexus block, or closed cyclopropane with curare to give relaxation.

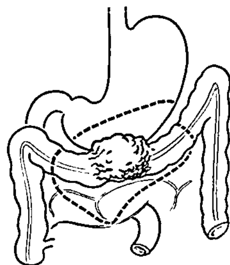


FIG. 159.—Resection of growth of transverse colon involving the stomach.

The operation has two objectives: the primary one of closing the fistula, the secondary one of curing the condition which gave rise to it.

Cancer of the colon

In cancer of the colon, the growth, with a liberal portion of the greater curvature of the stomach involved in the fistula, at least 3 inches of the colon on each side, and a wide V of transverse mesocolon down to the origin of the middle colic artery, should be resected in one block (Fig. 159). If a Friedrich-Petz clamp is available, the resection and closure of the stomach is greatly simplified. In most cases, the two ends of the transverse colon should be occluded temporarily by clamps, and the loops should be sewn together for 3 inches and brought out as a double-barrelled colostomy (Fig. 160). The intervening spur should be crushed after a few days, or drainage and restoration may be facilitated by the use of Zachary Cope's combined Paul's tubes and enterotome (Fig. 161). Under favourable conditions the ends of the colon may be joined by end-to-end anastomosis, pressure at the suture line being relieved by a temporary valvular caecostomy.

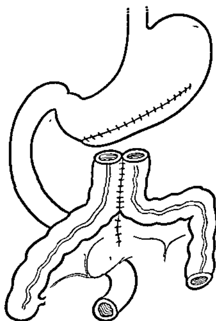


FIG. 160.—Resection of growth of transverse colon involving the stomach. Operation completed as double-barrelled colostomy, to be closed later.

In ulcerative colitis, a terminal ileostomy should be performed 2 inches above the ileo-caecal junction. The gastro-colic fistula will heal rapidly, and the colon may be resected, in stages if necessary, when the patient is stronger.

In an operation for the repair of a colonic fistula following gastro-jejunal ulceration, considerable time will be spent in establishing the anatomy of the lesion before any decision on operative detail can be made. In general, it is

best to use the former abdominal incision and, having found the peritoneal cavity, to start by detaching all structures from the anterior abdominal wall, then freeing omentum and stomach from the liver, lastly turning up the colon

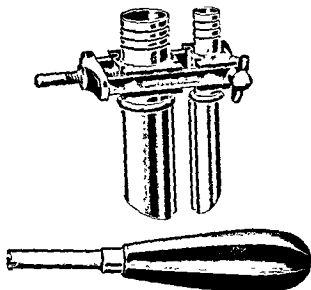


FIG. 161.—The Zachary Cope combined Paul's tube and enterotome (*Genito-Urinary Manufacturing Co. Ltd.*).

and identifying the stoma. Two problems arise, which may be considered separately.

(1) Detaching the colon from the stoma and repairing the hole.

(2) Resecting the old stoma and making a new one (Fig. 162).

(1) Treatment of the colon

The simplest treatment of the hole in the colon is by suture, but the repair is not technically simple. The hole is on the mesenteric border, and to clear the vessels around it enough to leave a ½-inch margin of healthy tissues, sufficient for safe invagination, is difficult. In the smallest holes closure by a double purse string may be possible; in larger ones a fair number of vessels must be ligated and the edges trimmed, so that invagination by two layers of sutures, the first interrupted, the second continuous, is advisable. In either case a proximal valvular caecostomy should be made round a 28 de Pezzer catheter, to relieve tension at the suture line (Fig. 163).

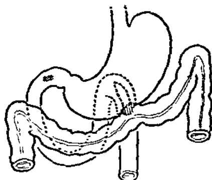


FIG. 162.—Gastro-jejuno-colic fistula.

Where the transverse mesocolon is widely involved in adhesions, resection

and obliterated by adhesions, *and an operation whose broad outlines only* can be planned beforehand. An intravenous drip should be running, and a suction tube passed through the nostril into the stomach before the operation starts. Every detail of lighting, instruments and assistance that can help should be available. The anaesthetic should be local with splanchnic plexus block, or closed cyclopropane with curare to give relaxation.

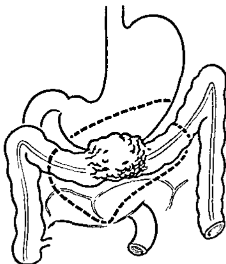


FIG. 159.—Resection of growth of transverse colon involving the stomach.

The operation has two objectives: the primary one of closing the fistula, the secondary one of curing the condition which gave rise to it.

Cancer of the colon

In cancer of the colon, the growth, with a liberal portion of the greater curvature of the stomach involved in the fistula, at least 3 inches of the colon on *each* side, and a wide V of transverse mesocolon down to the origin of the *middle colic artery,* should be resected in one block (Fig. 159). If a Friedrich-Petz clamp is available, the resection and closure of the stomach is greatly simplified. In most cases, the two ends of the transverse colon should be occluded temporarily by clamps, and the loops should be sewn together for *3 inches and brought out as a double-*barrelled colostomy (Fig. 160). The intervening spur should be crushed after a few days, or drainage and restoration may be facilitated by the use of Zachary Cope's combined Paul's tubes and enterotome (Fig. 161). Under favourable *conditions the ends of the colon may* be joined by end-to-end anastomosis, pressure at the suture line being relieved by a temporary valvular caecostomy.

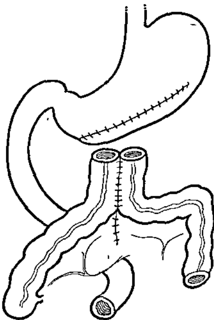


FIG. 160.—Resection of growth of transverse colon involving the stomach. Operation completed as double-barrelled colostomy, to be closed later.

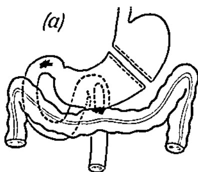
In ulcerative colitis, a terminal ileostomy should be performed 2 inches above the ileo-caecal junction. The gastro-colic fistula will heal rapidly, and the colon may be resected, in stages if necessary, when the patient is stronger.

In an operation for the repair of a colonic fistula following gastro-jejunal ulceration, considerable time will be spent in establishing the anatomy of the lesion before any decision on operative detail can be made. In general, it is

(3) Treatment of the stoma, when the previous operation has been a gastrectomy

In many cases the cause of ulceration is that the previous gastrectomy has not been sufficiently radical. The stoma must be resected and the jejunum repaired, the stomach must be cleared on the greater and lesser curvatures to a considerably higher level, and a fresh anastomosis must be made, using the jejunum below the repaired loop.

In the case of patients who have shown a marked tendency to ulceration in the past, the advisability of supra-diaphragmatic or *infra-diaphragmatic vagal* section should be considered if a post-operative test meal shows that even a high gastrectomy has not brought the acid secretion to a safe level.



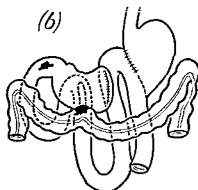


FIG. 166.—Exclusion gastrectomy. (*a*) The stomach divided. (*b*) Operation completed.

(4) Stage operations

(*a*) *Proximal colostomy*

Proximal colostomy has been advocated. This renders the stoma sterile, but does nothing to avoid the loss of nourishment. Sterilization is secured more simply by giving succinylsulphathiazole.

(*b*) *High exclusion gastrectomy*

By using the Friedrich-Petz clamp it is a relatively simple matter to divide the stomach into two portions, a high proximal segment to which a lower loop of jejunum is anastomosed, and a distal segment closed proximally into which the fistula opens (Fig. 166). This operation allows the patient once more to feed normally and restore his fluid and nutritional balance, and, in many instances, to heal his stomal ulcer and fistula. At a second operation, 6 weeks later, the distal portion including the stoma is resected, and the parts are left as in a one-stage radical operation (Fig. 167).

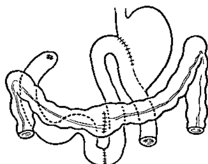


FIG. 167.—Radical operation following exclusion gastrectomy.

10. POST-OPERATIVE TREATMENT

Intravenous administration of fluids and gastric suction should be continued for 48 hours at any rate, usually for 4 days. The patient may be allowed to

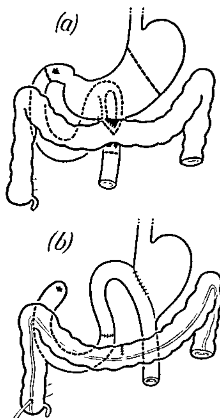


FIG. 163.—Radical one-stage operation for gastro-colic fistula following gastro-enterostomy. (*a*) Parts to be removed. (*b*) Operation finished.

the cut ends should be held in clamps, wrapped in swabs wrung out of flavine and laid aside, and brought to the surface as a double-barrelled colostomy at the end of the operation (Fig. 164).

(2) Treatment of the stoma, when the previous operation has been gastro-jejunostomy

In some cases the stoma may be detached, the openings in the stomach and the jejunum closed, and the normal anatomy restored (Fig. 164). This step is only possible when the distortion at the stoma is minimal and when the duodenum is of full patency. It is an unsatisfactory operation from the point of view of cure, only justified because it restores the patient at small risk to a condition in which he can once more take nourishment. It should be followed by gastrectomy after an interval of about 3 months (Fig. 165).

Usually, the whole segment of jejunum involved in the stoma must be resected, and the portions above and below joined end to end, the stoma itself being left on the stomach and closed temporarily by clamps on the afferent and efferent loops. The duodenum is divided and invaginated, and a high gastrectomy, removing at least four-fifths of the stomach, is performed. The exact form of gastrectomy performed is a matter of individual choice rather than of principle (Fig. 163).

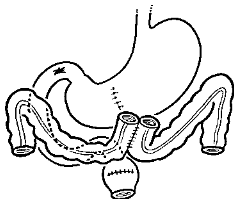


FIG. 164.—Gastro-jejuno-colic fistula. Two-stage operation. First stage: colon resected and anastomosis undone.

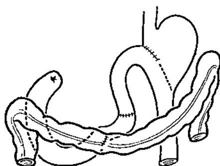


FIG. 165—Gastro-colic fistula. Two-stage operation. Second stage: radical gastrectomy.

GASTROSTOMY

BY A. J. C. LATCHMORE, M.B.E., M.S., F.R.C.S.
ASSISTANT SURGEON, GENERAL INFIRMARY, LEEDS; SURGEON, CLAYTON HOSPITAL, WAKEFIELD

1. INDICATIONS

165.] In general, the indication for this operation is to prevent starvation in oesophageal obstruction, and in practice it is largely confined to cases in which the obstruction is due to carcinoma of the oesophagus. It may be necessary occasionally as an emergency in wounds of the oesophagus and in severe corrosive burns, but it should hardly ever be necessary in fibrous stricture, because these strictures can almost always be dilated up if sufficient patience and skill are used. Dysphagia due to cardiospasm can also be relieved by repeated dilatation. It may also occasionally be found useful in obstruction from peptic ulcer of the oesophagus.

Carcinoma of oesophagus

At one time gastrostomy was the only available treatment for carcinoma of the oesophagus, but today the possibilities open to such an unfortunate patient are not nearly so limited, and much thought must be given to the matter before deciding upon this course.

(1) Inoperable growths

Souttar's tubes

These still form the large majority. If the case is to be treated by deep x-rays, gastrostomy should be done. Other cases can be treated either by gastrostomy or by intubation with Souttar's tubes. If a skilled oesophagoscopist is available these tubes can be inserted easily. Their widened upper end rests on the growth, and they may stay *in situ* for months without the patient being in any way conscious of their presence. He has the pleasure of eating and tasting and chewing, and the benefit of salivary digestion. The disadvantage of the method is that the tube sometimes slips past the growth and is passed per rectum and has to be reinserted. Occasionally also the tube becomes blocked as a result of a too ambitious meal and has to be cleared by oesophagoscopy. Gastrostomy has the advantage that it can be done by the general surgeon, and once done the danger of starvation is permanently averted, but it has the

drink fluids while the gastric tube remains in position. If, as is usually the case, there has been some peritoneal soiling, sulphathiazole should be administered for the first 2 days.

11. RESULTS OF TREATMENT

Mortality

The mortality of operation is necessarily high, in average hospitals about 40 per cent, in special clinics about 15 per cent, in small series by skilled gastric surgeons about 6 per cent. Those that recover should remain perfectly well.

Re-ulceration rate

The re-ulceration rate after high gastrectomy is 2 per cent at most; the patients in this group are admittedly ulcer prone, but by the time they have lived long enough to have chronic ulcers, gastro-jejunostomy, recurrent ulceration and gastrectomy, most of them have passed the peak of acid production.

BIBLIOGRAPHY AND REFERENCES

Brock, R. C. (1928). *Guy's Hosp. Rep.*, 78, 178.
Finsterer, H. (1939). *Surg. Gynec. Obstet.*, 68, 334.
Gray, H. K., and Sharpe, W. S. (1941). *Arch. Surg., Chicago*, 43, 850.
Hurst, A. F., and Stewart, M. J. (1929). *Gastric and Duodenal Ulcer.* London; Oxford University Press.
Mage, S. (1942). *Ann. Surg.*, 116, 729.
Ogilvie, W. H. (1935). *Lancet*, 1, 419.
Wilkie, D. P. D. (1934). *Ann. Surg.*, 99, 401.
[References to other titles are given under Gastro-Colic Fistula in the Index Volume.]

(2) The Stamm type

Curiously enough this type has commonly been attributed to Senn (1896). Senn's operation was a cone gastrostomy. In this—the best-known type—the stomach wall is invaginated by the series of purse-string sutures round the tube to form a valve like the neck of an unspillable ink bottle. The stomach is then stitched around the tube to the parietal peritoneum. In this type the track through the abdominal wall is lined with granulation tissue, not stomach mucosa, and tends always to contract, and therefore fits closely around the tube and remains continent. *Granulation-lined fistula*

(3) Tubo-gastrostomies

In these, a portion of the stomach wall is fashioned into a tube, which is either brought out through the abdominal wall or brought up subcutaneously on to the chest wall. The aim of these more complicated methods is to make a stoma with the following advantages: *Aim*

(a) It is less liable to leak. *Advantages*

(b) It allows the tube to be removed between feeds and avoids the continual wearing of an apparatus, and also avoids gastritis due to irritation from the tube.

(c) It does not contract and close if the tube is removed.

(d) Being free from scarring it facilitates anastomosis with a subcutaneous skin oesophagus.

(e) It allows a larger tube to be inserted, and thus facilitates natural swallowing when the cervical oesophagostomy is connected to the gastrostomy by a rubber oesophagus.

The respective merits of these various types are still *sub judice*. The following is only a guide in making this choice: *Respective merits*

(1) When done as a palliative the simplest procedure which will suffice is probably the best. The simplest method is the Stamm gastrostomy, and this is the only one which does not involve considerable opening of the stomach, which in debilitated patients must carry a serious risk. Leakage is a complication of some Stamm gastrostomies, and is said to be more rare in tubo-gastrostomies, but as new modifications of these procedures continue to be published it appears that these too are not always trouble free, even when safely accomplished.

(2) Tubo-gastrostomy should be done:

(i) When it has been decided that the growth is to be removed by the Torek type of operation.

(ii) In cases in which it is felt that the added risk of the more extensive operation is justified by the good condition of the patient, in the hope of making for him the ideal gastrostomy.

Of the various types of tubo-gastrostomy, the Janeway is probably the best.

4. THE STAMM GASTROSTOMY

The best anaesthetic is local block and infiltration. The amount of premedication should be carefully judged. Morphine, grain $\frac{1}{6}$, hyoscine, grain $\frac{1}{200}$, and atropine, grain $\frac{1}{100}$, will probably be adequate to bring these starved and weak patients to the theatre soundly sleeping. If it proves insufficient, the *Anaesthesia*

The "tube life" enormous disadvantages of being "a tube life" and of involving the sacrifice of gastronomic pleasure, which in old people is just as important as it is in the prime of life. In addition the operation does not cure the oesophageal obstruction; saliva and mucus still collect above it, and in growths of the lower end cause considerable distress. Finally, the operation has had in the past a high mortality, and the "tube life" is not devoid of complications.

(2) Operable growths

The outlook has greatly improved in recent years for those cases which are fortunate enough to be diagnosed early. Especially is this so in growths of the lower third of the oesophagus. *Present trend in oesophagectomy* The present trend is away from the Torek type of operation with its cervical oesophagostomy and gastrostomy connected by a rubber tube or by a subcutaneous skin oesophagus, because it has been found better to mobilize the stomach and draw it up into the chest to anastomose to the upper end of the divided oesophagus. This, of course, has an *Bearing on gastrostomy* obvious bearing on the question of gastrostomy, and means that gastrostomy should never be done in an early case until it has been decided whether any ultimate removal of the growth will be possible, and, if so, what type of operation is planned. When the full plan is made, then only is one in a position to decide whether to do a gastrostomy, and, if so, what type of operation to do.

2. PRE-OPERATIVE TREATMENT

Even when the simplest form of gastrostomy is performed under local *High mortality* anaesthesia *the operation is a serious one, and the mortality in the past has* been high. This is because the patients were so often suffering from starvation and dehydration, and their resistance was so lowered that they succumbed to peritonitis and post-operative chest conditions. With the precautions and methods described below the results should be much better.

Gastrostomy should never be done in these malignant cases as an emergency. If they are sufficiently starved and depleted to rank as an emergency *Fluid balance* they will not stand gastrostomy until their fluid balance has been restored by *the cautious administration of fluids intravenously for a few days.*

3. OPERATIVE TECHNIQUE

The fact that there are over 30 modifications of this operation indicates that there has been a good deal of dissatisfaction with the results. *Many modifications* Most of the modifications aim at avoiding leakage from the stoma. This, though fortunately rare, does occasionally occur, and is so distressing that it nullifies the good effects of the operation.

The various operations may be classified as follows.

(1) The cone type

A cone of stomach is brought out through the abdominal wall. It may be narrowed in two places to make a double valve, or brought out obliquely through or under the rectus muscle with the idea that the muscle presses upon it and keeps it closed. In time, however, the pressure of the tube straightens out the track and flattens the valves, and it is probable that continence of the stoma depends mainly upon the tube blocking the hole.

surface, midway between the two curvatures. The stomach is usually shrunken and there is little room to spare. A small incision is made in the selected spot, and with care to avoid leakage a Number 14 French catheter is inserted and stitched into the margin of the opening. A purse-string suture is then inserted ⅜ inch from the tube, and as it is tightened the tube is pressed inwards, thus forming a funnel-shaped depression in the stomach wall, with the opening pointing into the lumen at its apex. A second purse string is then inserted and the tube still further invaginated. A small hole is then made into the great omentum opposite the tube site and the tube drawn through it, so that the orifice is completely surrounded with omentum. The stomach is then sutured to the parietal peritoneum of each side with fine silk sutures and the abdomen closed.

5. THE JANEWAY TUBO-GASTROSTOMY

The same local anaesthesia is used. The incision may be an upper midline or a left rectus split. When the stomach is delivered and packed off, a rectangular flap on the anterior wall at right angles to the long axis of the stomach is marked out with Allis's forceps (Fig. 168 (a)). After ligating superficial vessels the incision is started at the free end of the flap, parallel to the lesser curvature. It is first made through the outer coats only, the mucosa picked up and the small hole made into it. The mucosa is then divided with scissors until the two Allis's forceps which mark the corners of the flap are reached (Fig. 168 (b)). These are then reapplied so that they grasp all layers of the stomach wall, and the cutting of the flap is then completed and haemostasis secured. A further Allis's forceps is then placed in the middle of the first incision and pulled upon, so that the rectangular deficiency in the stomach wall is converted into a triangle, with its sides in apposition (Fig. 168 (c)). The sides are then sutured together in two layers, starting at the Allis's forceps and continuing up the sides of the flap, sewing them together over a catheter and converting the flap into a tube (Fig. 168 (d)). The suture line and base of the pedicle are then reinforced with omentum, and the tube is brought out either through the incision or through a stab-incision in the left rectus near the costal margin if a midline incision has been used. The mucosa of the open end of the tube is then sutured to the skin.

6. THE JIANU TUBO-GASTROSTOMY

A midline supra-umbilical incision is made and the stomach delivered and packed off. The great omentum is then divided from the greater curvature distal to the left gastro-epiploic artery, which must be left as the blood supply to the tube which is to be made from the greater curvature (Fig. 169 (a)). A rubber-covered clamp is then placed up the long axis of the stomach midway between the two curvatures, and a second fully-curved clamp is applied to the fundus at the top of the greater curvature. These two clamps are so applied that the strip of stomach along the greater curvature is left empty. The right gastro-epiploic artery is then ligated, and the flap of the greater curvature cut right up to the fundus, sufficiently wide to make a tube nearly 1 inch in diameter (Fig. 169 (b)). The cut edges of the stomach and the tube are then closed in two layers (Fig. 169 (c)). The tube of greater curvature is temporarily closed at its end with an infolding stitch, and the subcutaneous tissues are tunnelled from the upper end of the wound to the site on the chest wall where the tube

smallest amount of Pentothal Sodium which will maintain sleep may be given during the operation. Novocain ½ per cent with adrenaline 1 : 50,000 is injected subcutaneously, and the whole of the left rectus muscle above the umbilicus is permeated with it, and some is introduced into the posterior sheath of the rectus.

Operation A vertical incision, 3½ inches long, is made from the costal margin, half-way across the left rectus muscle, the muscle is split and the two halves are

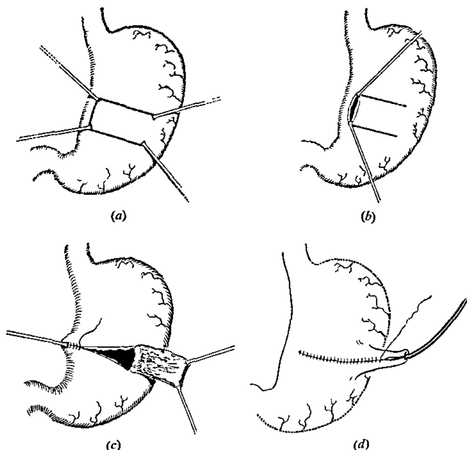


FIG. 168.—Janeway gastrostomy.
(*a*).—Rectangular flap marked out with four Allis's forceps.
(*b*).—Cutting of flap started at free end parallel to lesser curvature.
(*c*).—Allis's forceps placed on centre of the first incision parallel to the lesser curvature, and pulled upon so that the rectangular deficiency in the stomach wall is converted into a triangle with its sides in apposition. A suture is then begun at the Allis's forceps.
(*d*).—Suture continued up the edges of the flap, converting it into a tube round a catheter.

retracted. Before incising the peritoneum the posterior sheath of the rectus is again anaesthetized with a fine needle. After opening the peritoneum the two edges are lifted up and Novocain is injected into the parietal peritoneum, about 1½ inches from the incision on each side. The stomach is then delivered and examined and packed off, and the site for the gastrostomy chosen. This should be as far towards the fundus as possible on the anterior

Calorie value

for the first 24 hours, increasing to 4 ounces 2-hourly on the second day, 5 ounces on the third day and so on. The feeds are gradually worked up to 16 ounces. They should be given slowly, each feed taking 10 minutes. The diet must be calculated to contain adequate vitamins and to supply 3,000 calories per day, and the amount should not be left to the discretion of the patient, as, if this is done, it is often that failure to gain weight is due to a grossly inadequate diet.

Protein deficiency

There is a tendency for a fluid high-calorie diet to be relatively short of protein. In the early stages casein hydrolysates are useful, and later on many of these patients may be taught to feed themselves with semi-solids with a grease gun. This widens the diet and affords great satisfaction. King (1937) draws attention to the fact that the large amount of swallowed air which normally enters the stomach mixed with food is absent in gastrostomy feeding, and states that a mildly effervescent mixture given after feeds is beneficial.

8. COMPLICATIONS

(1) Early

Prevention

The main complications are peritonitis, wound infections and post-operative lung complications, all due to the lowered resistance of starvation, age and malignant disease. Hope of preventing them lies in fully recognizing the risks gastrostomy entails, in postponing operation until everything possible has been done by parenteral therapy to improve the patient's condition, and in limiting the complexity of the operation to one which it is estimated the patient can well stand.

Acute dilatation of stomach

A further important complication is acute dilatation of the stomach. This is apt to occur in the first few days and manifest itself by distress, by a rising pulse rate, and sometimes by a discharge of dark fluid from the fistula. The possibility of this should always be borne in mind, and if there is a deterioration in the condition of the patient or an unexplained rise in the pulse rate, suction should always be applied to the tube to rule out the presence of this condition. In the simpler gastrostomies ample precaution must be taken to avoid the tube being pulled out within the first ten days or so. Unless it is very securely fixed it may slip out, and attempts to reintroduce it may cause it to depart from the track and to be pushed into the peritoneum.

Fixation of tube

(2) Late

Leakage is the worst complication of gastrostomy. Most cases are due to breaking down of the stoma due to wound infection and trauma from unskilled reintroduction of the tube, but, whatever type of operation is done, a few cases are seen which leak intractably despite a satisfactory-looking stoma, and the mechanism in these is not fully understood. King (1937) suggests that the leakage is due to an increased gastric tension due to spasm of some part of the stomach wall. He believes that it is commoner when gastrostomy is performed for advanced growths of the lower end of the oesophagus, and suggests that involvement of the vagus or splanchnic nerves by the growth may cause this spasm. He states that when some symptom such as pain suggests that the growth in the lower part of the oesophagus has invaded adjacent structures, he now prefers to treat the case by jejunostomy.

In connexion with this important question of leakage it is well to remember

is to emerge. The tube is threaded through the tunnel and sutured in place with its end just protruding (Fig. 169 (d)). The greater omentum is then re-attached to the suture line on the stomach wall and the abdomen closed.

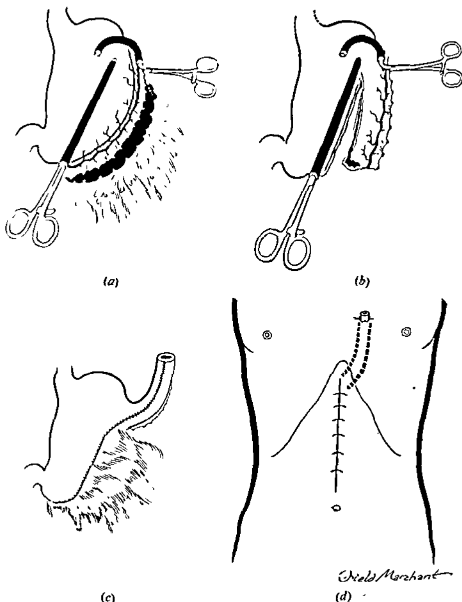


FIG. 169.—Jianu tubo-gastrostomy.

(*a*).—Great omentum divided distal to the left gastro-epiploic artery which must be left as blood supply to greater curvature. Clamps in position.

(*b*).—After ligation of right gastro-epiploic artery stomach is divided, and flap of greater curvature made.

(*c*).—Suture of divided stomach wall, and of the flap of greater curvature into a tube. Omentum re-sutured to stomach.

(*d*).—Subcutaneous tissues tunnelled from upper end of wound and tube brought out on chest wall.

7. POST-OPERATIVE CARE

Cautious initial feeding

Feeds should be started with small quantities of milk to accustom the alimentary tract once more to food. Feeds should be 3 ounces of milk 2-hourly

GENITAL ORGANS—FEMALE EXTERNAL

By J. ERIC STACEY, M.D., F.R.C.S. Ed., F.R.C.O.G.
Surgeon, Jessop Hospital for Women, Sheffield; Senior Lecturer in Obstetrics and Gynaecology, University of Sheffield

1. PRURITUS

166.] One of the most frequent symptoms arising from disease of the vulva is pruritus. In many cases, however, although a suspected cause of the itching has been removed, or a physical cause for the pruritus has not been found, the itching still persists. In such cases, Veit (1917) is of the opinion that the skin changes, together with the undermined nervous stability of the individual, account for the persistence of a symptom which ultimately becomes a disease. In other patients a definite psychoneurosis is the underlying cause of the affection. *Symptom or disease*

The symptom may be caused by such conditions as:

(1) Certain general diseases: for example, diabetes mellitus and jaundice.

(2) The presence of dirt and pediculi.

(3) Chronic irritating discharges arising from a neglected pessary, cervical catarrh, carcinoma of the cervix, pyuria, *Trichomonas vaginalis* infection and so forth.

(4) Leucoplakic vulvitis and kraurosis vulvae.

Much irritation occurs in the early stages of these conditions; this should disappear as soon as the underlying cause has been alleviated, but if it persists

that there is a relationship between the secretory activity of the stomach and its motility. Many of these cases have low acid values or achlorhydria, and if this is corrected by the administration of acid the leakage may be much lessened.

Achlorhydria

Diarrhoea

The same is true of the diarrhoea which gastrostomy patients are apt to develop. In the early days it is usually due to the introduction of food into a starved alimentary canal, but the later chronic forms are often achlorhydric in origin and greatly helped by acid.

Some patients complain of dyspepsia and symptoms of intestinal dysfunction without diarrhoea, and these often respond well to attention to the level of gastric acidity.

Stenosis of stoma

When the Stamm type of operation has been performed the patients must be warned that if they leave out the tube the opening will close very quickly. This is important, because in periods of relief from dysphagia the temptation to discard it is strong, and if this is done the fistula may close, and the operation may have to be repeated.

BIBLIOGRAPHY AND REFERENCES

King, E. S. J. (1937). *Brit. J. Surg.*, 24, 749.
Martin, H. E., and Watson, W. L. (1933). *Surg. Gynec. Obstet.*, 56, 72.
Senn, E. J. (1896). *J. Amer. med. Ass.*, 27, 1142.

[References to other titles are given under *Gastrostomy* in the Index Volume.]

rapidly remedied, by spontaneous cure by the commencement of a pregnancy, or by treatment, the condition usually persists and often assumes so aggravated a character that not only is there vulval spasm, but in some cases spasm of all the pelvic muscles, and often of the thigh muscles also; in other patients the slightest approach will lead to violent hysterical and almost epileptiform resistance. In such cases it is uncommon for the individual ever to become completely co-operative with the unintentional initiator of the trouble, and there are some judges of the High Court of Probate, Divorce and Admiralty who are so impressed with the certainty that the marriage never has been and never will be consummated, as to grant a nullity in the suit brought on these grounds alone.

Treatment

Treatment is by general psychological methods, supplemented by gradual vaginal dilatation and surgical enlargement of the introitus. The operation consists in incising the perineal body in the sagittal diameter, suturing the muscles transversely and covering the underlying tissues by suturing the edge of the perineum to the base of the perineal incision. *Psychological methods*

3. INFLAMMATORY DISEASES

A large number of organisms may set up inflammatory diseases of the vulva; such diseases may be of an acute or chronic character, and the latter may be ulcerative, atrophic or hypertrophic.

(1) Acute vulvitis

This is caused by many factors, for instance, a multiplication, under favourable conditions, of the bacteria which normally are found on the vulva—many of which are saprophytes capable of becoming facultative parasites—such as streptococci, staphylococci and *Bacillus coli*. Excessive secretions round the vulva often lead to vulvitis.

(2) Intertrigo

This is an acute diffuse condition often involving the vulva as well as the femoral and inguinal creases and is due to a maceration of the skin by moisture. The lesion causes burning and soreness and often generalized pruritus. The irritability, passing of urine, or contact of the clothes on the raw surface, produces intense pain. There is frequently an associated folliculitis accompanied by numerous small red papules which later become pustular. Such a condition not infrequently spreads into the deeper tissues of the dermis causing the appearance of multiple furuncles scattered over the labia majora and mons veneris; these may require incision before they clear up. *An acute diffuse condition*

(3) Gangrenous vulvitis

This condition is usually the result of a virulent infection gaining entrance to a laceration in a parturient woman—a wound which forms a large sloughing and gangrenous ulcer. It occurs also in debilitated women following extensive plastic or excision operations. *Infection of a laceration*

A more circumscribed form of gangrene known as noma is met with in small girls during acute infectious illnesses such as measles, scarlatina, typhoid

for any considerable length of time, the pruritus becomes a disease in itself, which will require treatment of the skin as well as measures directed towards raising the general resistance of the patient.

(1) Pathology

The skin of the affected area is flabby in consistency and of a greyish-white colour, with scoring or excoriation due to scratching. Depending upon the aetiology any part of the vulva may be affected, with frequent extension round the anus and inner sides of the thighs. Microscopic examination shows parakeratosis with an increase in keratin and eleidin cells, a hypertrophy of the papillary layer of the corium with irregularity of the Malpighian layer and an infiltration of the corium by leucocytes, chiefly polymorphs.

(2) Treatment

This consists in first applying remedies to cure the underlying cause, when *this can be found; should the symptoms persist as a disease, measures are* then taken towards anaesthetizing the skin area and applying general hygienic remedies. The parts are kept scrupulously clean and frequent bathing is resorted to in order to remove any irritating discharge. Bromides and hypnotic drugs are given to combat the loss of sleep and to reduce nervous irritability. Numerous lotions and ointments have been tried, most of which have only a transient effect. Amongst these may be mentioned Lotio Calaminae, lead and opium compresses, weak solution of carbolic acid and cocaine in the form of a solution or an ointment. Often, relief may be obtained by injecting the vulval area with various drugs, the effect of which is prolonged when they are administered in oily solution. Nupercaine, in oil and in mixtures of benzyl alcohol and ether, has been used with good results.

Resection of vulval nerves

Denervation of the vulva, either by severing the perineal nerve endings by undercutting the skin or, as in Manclair's operation, by cutting the internal pudendal nerve itself where it comes out of the pelvis, and combining this with section of the perineal nerve, has given relief in some cases.

Short-wave diathermy

Short-wave diathermy of the vulva, over many places in the affected area, has also met with success. In certain cases the administration of oestrin drugs, parenterally and orally as well as in the form of ointment locally, gives dramatic relief, and the exposure of the area to x-ray irradiation, or the insertion of radium needles into the skin, has been effected with equally striking results.

2. VAGINISMUS

Vulval spasm

Vaginismus is another affection of the vulva which is both a symptom and a disease. It consists of a vulval spasm which comes on with attempts at coitus. As a rule there are no local lesions associated with the condition, though in some cases highly sensitive abraded areas are seen in the vestibule, and in others a caruncular condition of the urethra is the cause of the phenomenon and is a defensive mechanism against further attempts at coitus. Most of the women suffering from the condition are highly strung and have usually led a particularly sheltered life. It is often elicited that, by innuendo or training, frequently by the mother, they have come to regard the marital act with repugnance. If, in addition, an unintentionally clumsy and often ignorantly brutal approach is made by the husband, then there is that combination of circumstances which leads so frequently to the production of the condition. Unless

Gonorrhoea in women is a self-limiting infection which will disappear as an infective lesion in one or two menstrual periods unless there is reinfection or the infection is transferred from place to place in the genital tract by repeated coitus or other irritant cause of transference. This must not be taken to imply that there will be no residuum of infection left behind—that there is such a legacy is proved by the frequently intractable inflammatory lesion of the urethra and of Bartholin's and Skene's glands. However, the infection which thus persists is the secondary infection brought about by other pyogenic organisms and the site has been, as it were, prepared for this secondary infection; the original cause has died out. Hence treatment by chemotherapy and penicillin alone is not accompanied by the same dramatic disappearance of symptoms and signs as is claimed for this treatment in the male. Unless such treatment is instituted in the very early acute stage, it is generally doomed to failure as regards complete and rapid disappearance of the inflammatory signs. Local treatment should, in the early stages, consist in gentle swabbing with mild antiseptics and the administration of urinary antiseptics. In the later stages treatment is directed towards clearing up the infection from the upper genital tract and dealing with the local sites of inflammation, and its complications such as abscess formation, by the methods employed in the treatment of inflammation elsewhere.

Self-limiting infection

(6) Vulvo-vaginitis of infants

A word must be said about the grievous prevalence of vulvitis in children—a condition which is frequently accompanied by vaginitis.

The disease in its characteristic form resembles gonococcal vulvitis in adults, and when the organisms are found on taking smears, the diagnosis is beyond doubt. Many cases, however, seem to be associated with the acute infectious fevers or are found in cases of threadworms which have spread from the anal tract to the vulva; in others, foreign bodies are found in the vagina, or the disease occurs without any determining cause being found at all.

Resemblance to gonococcal vulvitis in adult

The intractability of the disease is in some way related to the lesser degree of keratinization in the vestibule of young girls. This supplies the clue to the value of oestrogenic agents in the treatment of the disease, while not neglecting the local therapy dictated by circumstances and complications. A warning is required that such oestrogens must be given only a limited trial lest the side-effects of their use lead to undesirable sequelae.

4. CHRONIC CONDITIONS

(*Chronic Atrophic Vulvitis*)

(1) Kraurosis vulvae

Kraurosis vulvae was first described by Breisky in 1885 but Berkeley and Bonney in 1909 gave a more accurate description of the sclerosis of the vulval ring and deposition of yellow elastic fibrous tissue in the area of the vestibule—a simple non-leucoplakic sclerosis characteristic of kraurosis.

A non-leucoplakic sclerosis

In the early stages the skin is red and glistening, with purple or dark-red patches which later become pale yellow; the labial folds are obliterated and the atrophic mons veneris is covered by scanty broken hairs. At this stage the vaginal orifice is narrowed, rigid and sensitive, and there is dysuria;

fever and diphtheria. Treatment consists in scraping, excising or diathermizing the gangrenous areas under anaesthesia, treating the wound locally and the patient generally with sulphonamide drugs and penicillin, and using such other remedies as are applied to septic wounds elsewhere in the body.

It is not uncommon to find vulvitis associated with generalized infections, such as diphtheria, scarlatina and measles. In diphtheritic vulvitis the disease is generally secondary to lesions in the throat and nose. When vulvitis is encountered during an attack of measles or scarlatina, care should be taken to treat the vulval lesion with lotions and sulphonamides to prevent ascending infection into the vagina. The condition is a not uncommon cause of endocervicitis leading to sterility due to an acquired pin-hole os, which is usually diagnosed incorrectly as congenital in origin.

(4) Diabetic vulvitis

Irritant urine

Arising in the course of the systemic disease, diabetic vulvitis is so common as often to be the first symptom of the disease for which the patient seeks advice. The highly irritant urine, rich in sugar, passing over the vestibule and labia, causes the epithelium to become sodden and necrotic and the patient suffers from intense burning and pruritus. Micro-organisms and fungi grow in the subdermal tissues which become excoriated and infected by the scratching, and the whole vulva assumes a striking brick-red colour with indurated, greyish-white, ulcerated patches of a very characteristic type. When infiltrated by inflammatory exudate, mostly round cells and lymph, the presence of such a lesion may lead to an incorrect diagnosis of epithelioma. The treatment consists in the administration of the usual remedies to eliminate the hyperglycaemia, combined with local treatment.

Mention can be made only of such skin diseases of the vulva, often associated with vulvitis, as are caused by scabies, pediculosis pubis, monilia, mycoses, fungoides, tinea, herpes, actinomycosis, impetigo contagiosa and lichen affections.

Mention also must be made of granulomatous tuberculous vulvitis, but special attention must be given to venereal vulvitis caused by gonorrhoea and syphilis.

(5) Gonorrhoeal vulvitis

Contrary to the oft-repeated teaching that the gonococcus rarely attacks the vulva, it is a very frequent lesion in women and an almost invariable site of the infection in young children.

The infection shows itself in its early acute stage as a diffuse redness and oedema of the vestibule in particular, with purulent or blood-stained discharge exuding from the urethra and reddened Bartholin's ducts, in which is found the intracellular diplococcus.

In its more chronic stage it is often extremely difficult or impossible to demonstrate the organism and then the diagnosis rests on the history of the risk of exposure to infection, coupled, in some cases, with positive serological tests and the presence of signs and symptoms of gonorrhoea elsewhere in the genital tract. In the vulva there is redness of Bartholin's ducts, ectropion of the urethra accompanied by punctate redness, particularly of Skene's ducts, and milky-white exudate from both orifices.

5. CONDYLOMAS

Condylomas are almost invariably due to gonorrhoea, syphilis or other venereal infections. They are small or large, discrete or cauliflower-like excrescences, usually highly contagious, and they consist of hypertrophy of the papillary layer of skin, covered by thick epidermis. They rarely ulcerate or become friable, except in the special condition known as *esthiomène* in which these sessile or pedunculated tumours attain a large size, and are divided by deep fissures into convolutions. Histologically the lymphocytes and plasma cells of the condylomas are replaced in *esthiomène* by round-celled infiltration, a high degree of vascularity with endarteritis and much oedema.

Treatment is that of the causative organism, when this is found, coupled with surgical removal of the masses.

6. NEOPLASMS

(1) Benign

Simple tumours are of connective-tissue origin: fibromas, lipomas, adenomyomas and a few rare tumours such as angiomas and myomas. Epithelial benign tumours include papilloma, and condyloma acuminatum.

Of the connective-tissue tumours fibromas are the commonest variety. They grow in the subcutaneous tissue and are sessile or pedunculated or grow from the extra-abdominal part of the uterine round ligament. Hyaline and calcareous degenerative changes are common and about 20 per cent of the tumours undergo sarcomatous changes. The so-called adenomyoma of the vulva is generally a tumour of an ectopic ovary and usually shows the histology of a theca-lutein cyst.

(2) Malignant

(a) Incidence

About 5 per cent of cases of malignant disease in the pelvic organs in women occur in the vulva. The decade 61–70 provides the greatest incidence and there seems to be no relation to parity. There would appear to be a definite geographical distribution of the disease in Great Britain—the cotton-spinning districts of Lancashire, the dye-manufacturing area round Halifax and the silver-buffing region of Sheffield accounting for more than half the cases. Hendry, Stacey and others (1937) have suggested that this distribution has a relationship to the trades of the district in which bituminous oils rich in carcinogenic substances are particularly used. The labia majora are most commonly affected; following this, the clitoris, labia minora and then the other areas of the vulva are involved. In most cases the lesions are typical squamous-celled epitheliomas. *Geographical distribution*

The disease starts as a small wart or ulcer which soon invades the deeper structures of the area and rapidly ulcerates, leaving a crater densely fixed to the underlying structures. In the region of the clitoris or urethra these structures are soon involved and ultimately there is spread to periosteum or even to bone. During this process it is not uncommon for other separate patches to develop in various areas of the vulva, and to undergo similar metastatic spread by the lymphatics to the glands of the inguinal region *Metastasis*

later the soreness disappears leaving dyspareunia or apareunia as the only symptom.

Deficiency of oestrogenic factor

The most important factor in the aetiology is the deficiency of oestrogenic factor, and the treatment consists in the administration of synthetic or physiological substances of such nature, sometimes combined with operation to enlarge the introitus. The patient should be given 2 milligrams of stilboestrol or 5 milligrams of Oestroform twice daily for 1 month followed by 2 weeks' rest; this dosage is then repeated for 2 weeks in each of the 3 successive months.

(2) Leucoplakia vulvae

This term is used to include many conditions in which patches of keratinized corium occur under thickened epidermis, affecting the vulva and adjacent areas of skin.

In this article, however, only the condition known as leucoplakic vulvitis will be described.

Berkeley and Bonney (1909) defined the disease as "a chronic inflammatory lesion characterized by hyperaemia and cellular activity in the early stage, succeeded later by a phase of epithelial hypertrophy with a thickened, sclerosed and retracted subepithelial tissue". A part or the whole of the vulva is involved except that region of the vestibule and urethra which has developed from the urogenital sinus.

There are two stages of the disease. In the first the parts are red, excoriated and dry; later, this gives rise to the phase when the area becomes opaque and white with the appearance of cracks and fissures as the sub-epithelial tissues undergo retraction. It is then that epithelioma is so prone to develop and, though not an invariable sequel to the disease, this is possibly only because death occurs from some intercurrent affection.

(a) *Pathology*

Hypertrophy

The first stage of the disease is one of hypertrophy in which the epithelial layer is thickened and keratinized and the papillae are hypertrophied, dipping down deeply into the connective tissue. There are chronic inflammatory changes in the connective tissue, at times accompanied by oedema, associated occasionally with an absence of elastic tissue fibres in the sub-epithelial layer. The degree of hypertrophy is not constant in the same patient and the epithelial layer may be much thickened in one area but not in another. This makes it difficult to draw a rigid line between the stage of hypertrophy and the second stage which is one of atrophy.

Atrophy

The atrophic stage is characterized by thinning of the epithelial layer which, however, is not uniform since in some places areas of thickening and keratinization may remain. If the papillary processes hypertrophy during this stage an epithelioma may result.

(b) *Treatment*

The treatment of the disease is symptomatic, remedies being applied for the pruritus in the first stage and for the pain and ulcer formation in the second; unless rapid improvement results excision is then called for as prophylaxis against malignancy and, if the lesion proves to be cancerous, excision or other appropriate treatment is required.

GLAND-PUNCTURE AND ASPIRATION BIOPSY

By L. C. D. HERMITTE, M.B., Ch.B., D.T.M. & H.
Pathologist, Royal Infirmary, Sheffield; Lecturer in Pathology, University of Sheffield

and

FRANK ELLIS, M.Sc., M.D., F.F.R.
Director, Radiotherapy Department, London Hospital

1. FOREWORD

167.] The absolute diagnosis of the true nature of a "tumour" must finally rest upon histological evidence, for a purely clinical diagnosis may not only fall far short of the truth, but even when reasonably confident must inevitably harbour some element of doubt as to its correctness—an important consideration when the real value of some specific treatment comes to be assessed later, particularly in the case of neoplasms for which cures are claimed. *Importance of histological evidence*

Histological evidence prior to treatment (operative or otherwise) postulates a biopsy.

2. DEFINITION

"Needle biopsy" may be defined as an attempt to obtain from a lesion by means of a hollow needle, a small, representative portion of solid tissue for the purpose of establishing, by histological technique, an absolute diagnosis of the true nature of the lesion. *"Needle biopsy"*

Aspiration of material, for microscopical, bacteriological and parasitological examination, has been practised for many decades in such specific instances as serous cavities, fluctuating swellings, liver, spleen and bone marrow, but the possibility of using a hollow needle for obtaining solid material for histological treatment was not generally appreciated until Martin and Ellis (1930) elaborated the method in the diagnosis of lesions suspected of being neoplastic. Since then, its practice in this sense has been extended and its results have been reported by them (1934, 1940) and by many other workers (Ferguson, 1930; Coley, Sharp and Ellis, 1931; Stewart, 1933;

and Scarpa's triangle. Dissemination is early and invasion of the femoral ring, with fixity to the vessels, is quite common; fatal haemorrhage may ensue. Further spread is to the iliac and lumbar glands but gross metastases in other viscera are uncommon.

(b) Symptoms

The symptoms are usually superimposed on those of the predisposing leucoplakia and take the form of pain and burning accompanied by a serous or blood-stained discharge. The later symptoms, such as retention or incontinence of urine and pain in the hip or down the leg, are those due to spread to the deeper structures.

Later symptoms

(c) Treatment

Treatment is usually operative or by irradiation therapy, but Stacey and Ellis (1939) have shown that the best results can be achieved by a combination of the two measures.

Operation aims at a radical cure or is undertaken to alleviate the symptoms. If the aim is alleviation, then all that is done is a local excision of the growth; this is best carried out by diathermy.

Technique of Barret

The curative operation is best undertaken by the technique of Barret, which involves a block dissection not only of the vulva but also of as many of the inguinal and femoral glands as it is possible to remove. The primary mortality of this operation is so high, and the late survival rate so low, that it is now becoming the practice to combine radiotherapy with operation.

If radium alone is used, great difficulty is experienced in providing adequate dosage because movements of the patient alter the position of needles or plaques relative to the growth, and so the calculated dose either is exceeded or is not reached. In spite of the use of a method elaborated by Ellis to overcome this defect, the best results are obtained by irradiation of the primary growth and the glands, followed by excision of the vulva.

REFERENCES

Berkeley, C., and Bonney, V. (1909). *Proc. R. Soc. Med.*, **3**, 29.
Breisky (1885). *Wien. med. Wschr.*, **35**, 208.
Henry, S. A., Stacey, J. E., *et al.* (1937). *Personal Communication.*
Stacey, J. E., and Ellis, F. (1939). *Proc. R. Soc. Med.*, **32**, 304, 307.
Veit, J. (1917). *Frauenarzt*, **32**, 242.

[References to other titles are given under Genital Organs—Female External in the Index Volume.]

(3) Cases in which an ordinary surgical biopsy could not be obtained without a major surgical operation, particularly when such a major operation would be unlikely to allow of the successful removal of the tumour.

(4) It is the only method feasible in the case of deep-seated lesions (suspected of being neoplastic) within the thorax, cranium, other bones and even within the abdominal cavity. *Deep-seated lesions*

In the case of bronchial cancer, however, needle biopsy should be reserved for cases in which bronchoscopy has failed to yield positive evidence in spite of strong clinical indications, and provided the risk of spreading bacterial infection has been minimized by appropriate chemotherapy.

5. THE AUTHORS' EXPERIENCE

The authors co-operated at the Royal Infirmary, Sheffield, in the performance and histological study of large numbers of needle biopsies from such sources as superficial but closed neoplasms and other swellings, including recurrent nodules of carcinoma after surgical excision and irradiation, from the scalp, ear, face, mouth, tongue, pharynx, various regions of the neck, axillae, inguinal regions (particularly adenopathies), chest and abdominal walls, back, limbs, penis, scrotum, vulva, vagina and cervix uteri, and from deeper lesions situated within the cranium, orbit, antrum, mediastinum, lungs, breast, abdomen, ischio-rectal fossa, prostate, testis, and bones including lower jaw, sternum, clavicle, ribs, scapulae, spine, pelvic and limb bones, with a very satisfactory proportion of positive results helpful in diagnosis (63 per cent of 689 biopsies, of which a certain number were dealt with by Dr. J. H. Barrie, Pathologist at the Royal Hospital, Sheffield). Of these, 368 cases or approximately 53 per cent were correctly returned as malignant, and the remaining 10 per cent as benign neoplasms or other pathological lesions.

6. CONTRA-INDICATIONS

Needle biopsy should be avoided in cases of pulmonary or mediastinal lesions suspected of being infected or in patients known to be suffering from emphysema, suspected aneurysms and suspected hydatid cysts.

7. DISADVANTAGES

The disadvantages of needle biopsy are real though few.

(1) In a certain percentage of cases a single attempt fails to obtain sufficient tissue for diagnosis. This failure varies, however, with the operator and diminishes with experience, practice and care. *Failure to obtain sufficient tissue*

(2) The greatest disadvantage lies in the smallness of the fragments of tissue and their liability, in a small proportion of cases, to become distorted. Distortion may be due to delayed fixation or possibly to the mechanical effect of suction or tearing by a blunt needle. It is essential to use a sharp needle and to guard against drying. *Distortion*

These disadvantages often prove a source of strain upon the patience of the pathologist who has to be satisfied with a "few bricks" as it were instead of a "wall", but familiarity with these "bricks", bred from experience and practice, will in a large percentage of cases enable him to extract from them

Blinkenberg, 1938; Baron, 1939; Binkley, 1939; Iversen and Roholm, 1939; Sayago, 1942; Wrenn and Feder, 1942; Christiansen, 1942; Valls, Ottolenghi and Schajowicz, 1942; Hermitte and Ellis, 1947.)

3. ADVANTAGES OF THE METHOD

The advantages of needle biopsy are clear.

(1) While it is generally admitted, on the one hand, that there is little risk in carefully punching out or removing by scalpel (surgical biopsy) a small portion of tissue from an exposed ulcerated surface (skin, nose, mouth, rectum, uterine cervix and even bronchus) for histological examination, it is, on the other hand, generally accepted, with Ewing, that a surgical biopsy through normal tissues is fraught with danger because such a procedure is liable to break down local barriers to the spread of infection and, in the case of neoplasms, to favour early metastases, local carcinomatosis (Fig. 170 (1)) or fungation of the growth through the surgical wound.

Danger of surgical biopsy through normal tissues

Since, however, injury to normal tissues surrounding a lesion is minimal because of a mere needle puncture which, after removal of the needle, is quickly sealed by retraction of the tissues (and probably by a thin cylindrical blood clot in addition), needle biopsy offers an ideal method of obtaining pathological material through normal tissues at negligible risk.

Negligible risk

(2) The operation is comparatively simple, can be completed in a few minutes and is eminently suitable for out-patients or for patients *à domicile*, thus rendering unnecessary the admission of patients into hospital and the preparation and expense attached to the use of a surgical theatre.

Repetition not contra-indicated

(3) While failure to obtain positive evidence at a first attempt (which is one of the few disadvantages of the method) does not rule out the presence of a diagnosable lesion, when the clinical data strongly suggest its presence, the biopsy can be repeated several times if necessary, without undue risk, until satisfactory material is obtained.

(4) The indications for its use are wide, and few lesions, particularly of a neoplastic nature which would otherwise remain undiagnosed, need remain without a diagnosis.

4. INDICATIONS

Needle biopsy is indicated for the following conditions.

Lymph glands

(1) Enlarged lymph glands. In cases suspected of metastatic cancer removal of a lymph gland for diagnostic purposes should never be attempted. Needle biopsy is the method of choice and rarely fails to yield positive evidence in such cases (Fig. 170 (1)).

In cases suspected of Hodgkin's disease, requiring *differential diagnosis* from other adenopathies, the common practice of removing a lymph gland for histological examination may be rendered unnecessary if a needle biopsy proves positive, whatever the lesion.

In any case, it is always advisable to aspirate the selected gland first to exclude metastatic cancer.

Closed tumours

(2) Any palpable tumour lying deep to the surface and covered by normal tissues, particularly breast tumours when diagnosis of malignancy is in doubt, or when, although diagnosis of cancer is clear, radical amputation is contra-indicated.

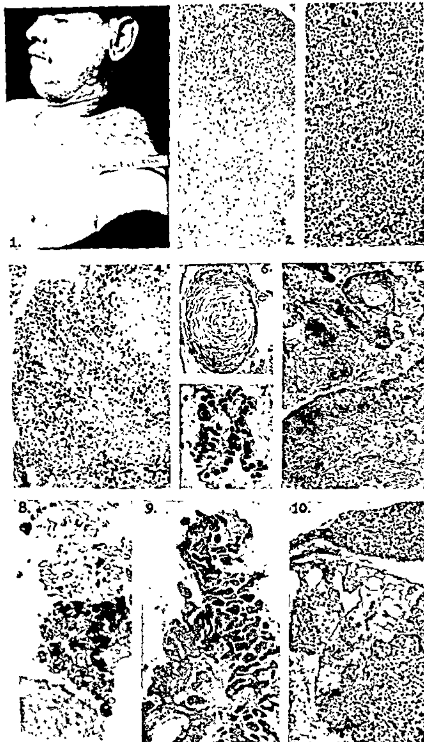
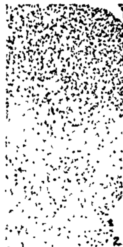

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

FIG. 170.—Illustrations 2–36 are of simple needle biopsies; 37–44 are of drill biopsies; 5, 7, 8, 11, 13, 22, 23, 24 and 25 are examples of extremely small biopsies susceptible of accurate diagnosis.

(1) Carcinomatosis of skin resulting from a surgical biopsy of a lymph gland invaded by metastases from a primary adenocarcinoma of the kidney. The features are extremely pale and the area of carcinomatosis mottled red and yellow.
(2) Caseous tissue surrounded by reticulo-lymphocytic reaction (T.B. +), from cervical lymph gland (× 130).
(3) Typical Hodgkin's lesion containing Dorothy Reed cells, from cervical lymph gland (× 130).
(4) Metastatic melanocarcinoma from left inguinal lymph gland (× 65).
(5) Single cornified squamous epithelial pearl (grade 1 squamous epithelioma) from cervical lymph gland (× 130).
(6) Grade 2 squamous epithelioma from cervical lymph gland (× 75).
(7) Metastatic adenocarcinoma from cervical lymph gland (× 305).
(8) Small portion of anaplastic carcinoma containing several mitotic figures (× 300).
(9) Basal-cell carcinoma from inner canthus of eye (× 60).
(10) Grade 3 squamous epithelioma of neck invading fat (× 80).
(11) Scirrhous adenocarcinoma of breast (× 90).
(12) Papillary spheroidal cell adenocarcinoma of breast among a mass of red blood cells (× 90).
(13) Mucoid (colloid) adenocarcinoma of breast (× 60).
(14) Metastatic adenocarcinoma simplex of breast from axillary lymph gland (× 90).
(15) Medullary adenocarcinoma of breast (× 100).
(16) Portion of abscess wall from breast (× 100).
(17) Mixed tumour of salivary gland from mouth (× 90).
(18) Colloid goitre (× 90).
(19) Primary adenocarcinoma of thyroid gland (× 130).
(20) Metastatic well-differentiated adenocarcinoma (so-called metastasizing adenoma) of thyroid gland from skull (× 80).
(21) Metastatic adenocarcinoma of prostate from swelling on medial surface of rib. *(By courtesy of Dr. J. H. Barrie.)*
(22) Adenocarcinoma invading abdominal operation scar (× 130).
(23) Metastatic adenocarcinoma from liver (× 100).
(24) Metastatic Wilm's embryoma from liver (× 130). (Malignancy was diagnosed but the type of growth was only settled at post-mortem examination.) It was an unusually glandular growth particularly in its metastases.
(25) Metastatic adenocarcinoma of ovary in aspirated peritoneal fluid centrifuged and sectioned.
(26) Fluid aspirated from branchial cyst showing epithelial squames, lymphocytes and cholesterol crystals (wet preparation) (× 60).
(27) Fluid aspirated from hydatid cyst showing hooklet of *Echinococcus granulosus* (diagnostic), cholesterol crystals, fatty globules and granular debris.
(28) Two colonies of *Streptothrix actinomyces* surrounded by purulent exudate aspirated from right inguinal fossa (× 90).
(29) Sacro-iliac osteoclastoma (× 130).
(30) Myxo-chrondroma from head of humerus (× 130).
(31) Osteo-chondrosarcoma of maxilla (× 130).
(32) Plasma cell myeloma aspirated from sternum (× 300).
(33) Myelocytic myeloma aspirated from upper end of humerus. The cells belong to the granuloblastic series, showing many mitoses and even young eosinophils (× 300).
(34) Metastatic breast carcinoma from sternum (× 130).
(35) Portion of neurinoma (schwannoma) of spinal nerve aspirated from swelling near angle of jaw and showing typical palisading of nuclei of neoplastic Schwann cells (× 130).
(36) Pleomorphic fibrosarcoma aspirated from pubis in a case of Paget's disease (× 130).
(37) Hodgkin's tissue from cervical lymph gland (× 225).
(38) Post-hepatic fibro-neurosarcoma aspirated through liver (× 220).
(39) Ewing's tumour of ankle. Patient died with metastases in lungs.
(40) Adenoma of parotid gland, probably benign (× 240).
(41) Scirrhous carcinoma of breast (stained Van Gieson) (× 130).
(42) Adeno-lymphoma of parotid gland (× 34).
(43) Metastatic bronchial carcinoma from liver (× 57).
(44) Primary adenocarcinoma of prostate (× 75).

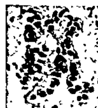

1.


2.




4.


6.


7.




8.


9.


10.

FIG. 170.—Illustrations 2–36 are of simple needle biopsies; 37–44 are of drill biopsies; 5, 7, 8, 11, 13, 22, 23, 24 and 25 are examples of extremely small biopsies susceptible of accurate diagnosis.

(1) Carcinomatosis of skin resulting from a surgical biopsy of a lymph gland invaded by metastases from a primary adenocarcinoma of the kidney. The features are extremely pale and the area of carcinomatosis mottled red and yellow.

(2) Caseous tissue surrounded by reticulo-lymphocytic reaction (T.B. +), from cervical lymph gland (× 130).

(3) Typical Hodgkin's lesion containing Dorothy Reed cells, from cervical lymph gland (× 130).

(4) Metastatic melanocarcinoma from left inguinal lymph gland (× 65).

(5) Single cornified squamous epithelial pearl (grade 1 squamous epithelioma) from cervical lymph gland (× 130).

(6) Grade 2 squamous epithelioma from cervical lymph gland (× 75).

(7) Metastatic adenocarcinoma from cervical lymph gland (× 305).

(8) Small portion of anaplastic carcinoma containing several mitotic figures (× 300).

(9) Basal-cell carcinoma from inner canthus of eye (× 60).

(10) Grade 3 squamous epithelioma of neck invading fat (× 80).

(11) Scirrhous adenocarcinoma of breast (× 90).

(12) Papillary spheroidal cell adenocarcinoma of breast among a mass of red blood cells (× 90).

(13) Mucoid (colloid) adenocarcinoma of breast (× 60).

(14) Metastatic adenocarcinoma simplex of breast from axillary lymph gland (× 90).

(15) Medullary adenocarcinoma of breast (× 100).

(16) Portion of abscess wall from breast (× 100).

(17) Mixed tumour of salivary gland from mouth (× 90).

(18) Colloid goitre (× 90).

(19) Primary adenocarcinoma of thyroid gland (× 130).

(20) Metastatic well-differentiated adenocarcinoma (so-called metastasizing adenoma) of thyroid gland from skull (× 80).

(21) Metastatic adenocarcinoma of prostate from swelling on medial surface of rib. *(By courtesy of Dr. J. H. Barrie.)*

(22) Adenocarcinoma invading abdominal operation scar (× 130).

(23) Metastatic adenocarcinoma from liver (× 100).

(24) Metastatic Wilm's embryoma from liver (× 130). (Malignancy was diagnosed but the type of growth was only settled at post-mortem examination.) It was an unusually glandular growth particularly in its metastases.

(25) Metastatic adenocarcinoma of ovary in aspirated peritoneal fluid centrifuged and sectioned.

(26) Fluid aspirated from branchial cyst showing epithelial squames, lymphocytes *and cholesterol crystals (wet preparation) (× 60).*

(27) Fluid aspirated from hydatid cyst showing hooklet of *Echinococcus granulosus* (diagnostic), cholesterol crystals, fatty globules and granular debris.

(28) Two colonies of *Streptothrix actinomyces* surrounded by purulent exudate aspirated from right inguinal fossa (× 90).

(29) Sacro-iliac osteoclastoma (× 130).

(30) Myxo-chrondroma from head of humerus (× 130).

(31) Osteo-chondrosarcoma of maxilla (× 130).

(32) Plasma cell myeloma aspirated from sternum (× 300).

(33) Myelocytic myeloma aspirated from upper end of humerus. The cells belong to the granuloblastic series, showing many mitoses and even young eosinophils (× 300).

(34) Metastatic breast carcinoma from sternum (× 130).

(35) Portion of neurinoma (schwannoma) of spinal nerve aspirated from swelling near angle of jaw and showing typical palisading of nuclei of neoplastic Schwann cells (× 130).

(36) Pleomorphic fibrosarcoma aspirated from pubis in a case of Paget's disease (× 130).

(37) Hodgkin's tissue from cervical lymph gland (× 225).

(38) Post-hepatic fibro-neurosarcoma aspirated through liver (× 220).

(39) Ewing's tumour of ankle. Patient died with metastases in lungs.

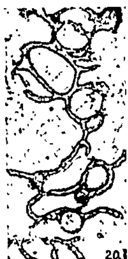
(40) Adenoma of parotid gland, probably benign (× 240).

(41) Scirrhous carcinoma of breast (stained Van Gieson) (× 130).

(42) Adeno-lymphoma of parotid gland (× 34).

(43) Metastatic bronchial carcinoma from liver (× 57).

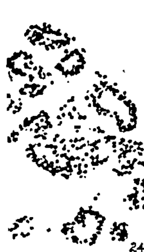
(44) Primary adenocarcinoma of prostate (× 75).

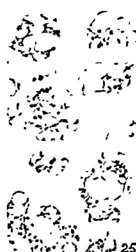

20


21


22


23

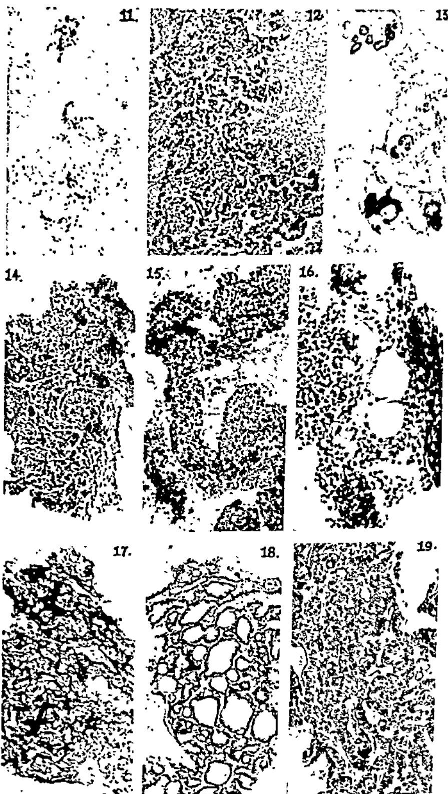

24


25

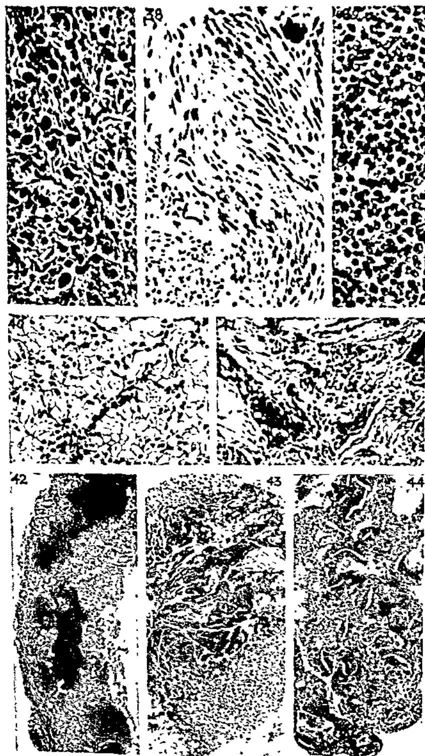

26

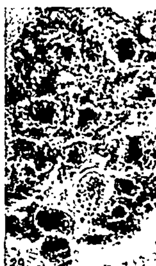

27


28



11.
12.
13
14.
15.
16.
17.
18.
19.


38
40
41
42
43
44

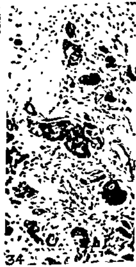

29

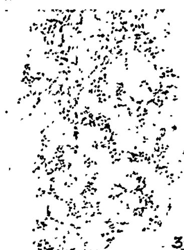

30




32




34


35


36

The solution is made up as follows:

Picric Acid	5 grammes
Spirit	750 cubic centimetres
Formaldehyde	300 cubic centimetres
Glacial Acetic Acid	150 cubic centimetres

Note: (1) The aspiration syringe should be rinsed with citrate solution just before the operation so as to prevent the coagulation of any blood that might be withdrawn. (2) About 1 cubic centimetre of the selected fixative should be placed in the selected receiving tube just before the operation. More fixative used for rinsing out the syringe and needle after the operation is added later.

9. TECHNIQUE

There are at present two methods in use.

(1) The original method devised by Martin and Ellis (1930), utilizing a 20 cubic centimetre Record syringe and 18-gauge (or wider) sharp-pointed hollow needle.

(2) A drilling method based upon a modification by Christiansen (1940), of one devised by Kirschner of Heidelberg (1934), utilizing a trephine-like flat ground hollow needle with sharply bevelled edges, adapted to a drilling machine as used by dentists.

(1) Method I—simple puncture and aspiration

Aseptic precautions

The skin is cleansed as for any surgical procedure and an intradermal weal made with 2 per cent Novocain solution at the site chosen for puncture. If the lesion is deeply situated it is desirable to introduce the local anaesthetic down to its surface, or a nerve-block technique may be used at the discretion of the surgeon.

Stab incision

Before introducing the aspiration needle a small stab incision should be made through the skin at the site chosen for puncture. The stab incision through the skin is always advisable, otherwise the aspirating needle is liable to get blocked with a small disc of firm normal epidermis which prevents softer tissues from entering the needle and eventually proves to be the only finding in the finished histological preparation.

Fixation of lesion

The tumour should now be fixed as firmly as possible or its position indicated by some guiding device or manoeuvre.

Tumours palpable upon the surface, particularly lymph glands, should be fixed with the thumb and forefinger of the left hand, and those in the submaxillary region with one finger in the mouth; in the case of the prostate (using the perineal route) the left forefinger is introduced into the rectum as a guide; approach to mediastinal or lung tumours, or to metastases in bone, should be guided by suitable x-ray pictures; lesions within the abdominal cavity, however, must be approached with extreme care and after ascertaining by palpation and percussion that there is no intervening intestine.

Suction

The needle is introduced through the stab incision and, when it has reached the surface of the lesion, the syringe (previously rinsed with citrate solution) is attached, the piston withdrawn to produce suction, and kept withdrawn by the right thumb and forefinger pressing against the barrel.

While maintaining suction the needle is pushed into the lesion as far as its estimated deep aspect. Failure to maintain suction while the needle is being

positive information of diagnostic value both to the surgeon and the patient. Since it is the patient who must be the primary consideration the pathologist must and does accept the inevitable. On the other hand, although the information obtained is frequently as complete as that obtainable from a good surgical biopsy, the surgeon must, in many cases, remain satisfied with less than the usual detailed report.

ccidents (3) Accidents are not altogether averted by the method. Haemorrhage has been reported from accidental puncture of the carotid artery (once) and of the femoral artery (once) but in each case it yielded to local pressure, after withdrawal of the needle, without further incident.

To judge from the experiences of numerous workers who have published their results in thousands of needle biopsies during the last fifteen years, accidents are extremely rare, very seldom prove fatal and hardly constitute a risk in the great majority of cases.

No one has reported the occurrence of local carcinomatosis after a needle biopsy.

The danger of spread of infection can be minimized by appropriate chemotherapy.

8. PRE-OPERATIVE REQUIREMENTS

(1) A sterile 20 cubic centimetre Record syringe with well-fitting 18-gauge (or wider) needle.

For Method I, the needle must be sharp-pointed and provided with a stilette.

For Method II, the needle must be ground flat with sharply bevelled edges after the fashion of an eye trephine and provided with a suitable trocar.

In both cases the needle should be about 6 centimetres long for the average lesion. For intrathoracic and other deep-seated lesions a longer needle is necessary.

(2) Sterile 2 per cent Novocain solution, with a suitable syringe and needle.

(3) Sterile 3·8 per cent sodium citrate solution (as an anti-coagulant in case blood is aspirated).

(4) Suitable receptacles for the biopsy material—at least two of each of the following:

- (a) Centrifuge tubes provided with cork stoppers (suitable for small fragments of tissue or small quantities of blood);
- (b) Flat-bottomed tubes, $\frac{3}{4}$–1 inch in diameter, provided with cork stoppers (suitable for appreciable quantities of blood);
- (c) Sterile test-tubes provided with cork stoppers (for fluid or pus which may require bacteriological or microscopical examination before fixation).

(5) Fixative fluid: Any suitable cytological fixative may be used but the following are recommended:

- (a) 10 per cent formol saline solution (for use when a report is not urgently required);
- (b) Masson's alcoholic picroformol (for use when a report is urgently required; being alcoholic it reduces dehydration time, and the section can be prepared and the report issued within 2 hours).

manipulated within the tumour is probably the most frequent cause of failure to obtain sufficient tissue, for aspiration alone with the needle at rest is not sufficient to draw tissue into the needle.

Still maintaining suction, the needle is now withdrawn for a distance of about a quarter of an inch and then pushed in again for the same distance at an angle of about 30 degrees to its previous direction—this cuts off the column of tissue already in the needle.

Suction still being maintained, the needle may be withdrawn to the surface of the lesion and reintroduced as before, in a different direction through the whole thickness of the lesion, and the cutting process repeated. When this has been done two or three times, the suction is released very slowly and the syringe detached from the needle. *Release of suction*

The needle is now removed and bleeding, if any, stopped by pressure over a pad of sterile gauze, and a small dry dressing applied over the stab wound and kept in position by a short length of strapping. The latter step should preferably be left to an assistant to enable the operator to deal immediately with the biopsy which may otherwise be spoiled through drying. Drying must be carefully guarded against. *Avoidance of drying*

The syringe is now filled with air, readjusted to the needle and the contents of the latter expelled into fixative in the prepared container which may be: *Fixative*

(a) A centrifuge tube for small fragments of solid tissue or a very small quantity of blood; or (b) a flat-bottomed tube of wider bore for an appreciable quantity of blood; or (c) a sterile test-tube for an appreciable quantity of fluid whether clear, turbid or purulent. In this case fixative must not be added.

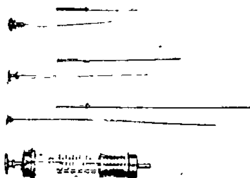


FIG. 172.—Record syringe and various sizes of trephine needles with trocars used in drill biopsies.

Finally the syringe is attached to the needle, some fixative drawn up into it, inverted several times and the contained fixative expelled through the needle into the receiving tube in such a way as to wash down any tiny pieces of tissue which might have adhered to the sides of the container. As already stated, drying must be carefully guarded against. *Rinsing of syringe and needle*

Additional precautions

(a) If the tissue is hard to expel from the needle (for example, bone or cartilage) it should be pushed out with a stilette. Indeed the stilette should be pushed through the needle as a final precaution after the terminal rinsing fixative. *Use of stilette*

(b) If much blood or fluid is obtained this will be sucked up into the syringe carrying with it any fragments of solid tissue. In such cases a few minutes spent in searching for and picking out these small pieces of tissue from the

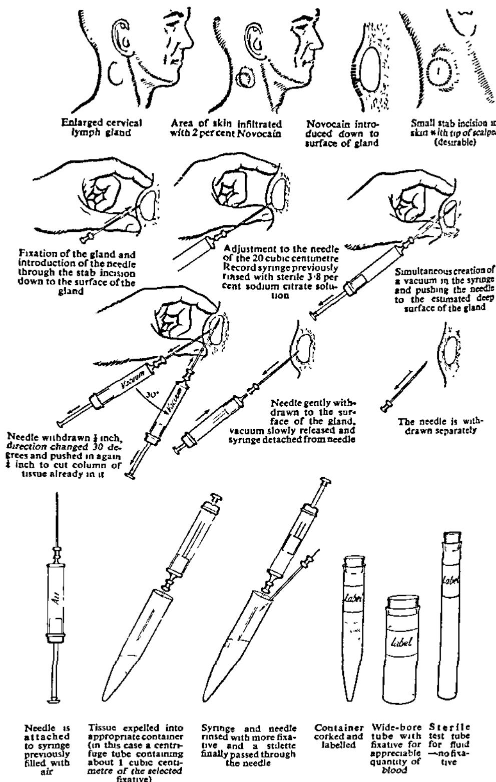


FIG. 171.—Steps in the performance of a needle biopsy on an enlarged lymph gland.

RESULTS OF DRILL BIOPSIES AS COMPARED WITH THOSE OF SIMPLE NEEDLE BIOPSIES

Regions	Simple Needle Biopsies		Drill Biopsies	
	Total No.	Satisfactory	Total No.	Satisfactory
		Per cent		Per cent
Lymph glands –	280	63	96	65
Breast – –	108	56	21	90
Bone – –	87	67	37	68
Lung – –	18	56	9	75
Intra-abdominal –	13	64	10	80
Prostate – –	10	35	8	50
Total – –	516	55	181	71

Only biopsies from identical sources are given

[All drill biopsies were performed by Dr. Ellis at the Radiotherapy Department, London Hospital, and reported on by Dr. Woods, Pathologist, London Hospital.]

10. IMPORTANCE OF SUPPLYING CLINICAL DATA WITH ALL BIOPSIES

Much time can be saved and trouble spared to the pathologist if the clinician sees to it that every biopsy is accompanied by relevant clinical data such as its exact origin, the exact position of the lesion, its duration, any recent change in its behaviour, the age, sex and present condition of the patient, x-ray findings if any, result of Wassermann reaction if available and whether or not the lesion had been previously irradiated.

When a report is required urgently this should be stated.

Provided the material has been placed in Masson's fixative a report on a good paraffin section can be issued within two hours of receipt of the biopsy.

11. INTERPRETATION OF BIOPSIES

This is the responsibility of the pathologist. That correct interpretation can confidently be made upon the material available in the majority of cases, can best be judged by the series of photomicrographic illustrations on pages 301–305.

BIBLIOGRAPHY AND REFERENCES

Baron, E. (1939). *Arch. intern. Med.*, 63, 276.
Binkley, J. S. (1939). *Amer. J. Cancer*, 36, 193.
Blinkenberg, P. A. (1938). *Nord. med. Tidskv.*, 1, 1343.
Christiansen, H. (1940). *Acta. radiol. Stockh.*, 21, 349.
— (1942). *Ibid.*, 23, 147.
Coley, B. L., Sharp, G. S., and Ellis, E. B. (1931). *Amer. J. Surg.*, 13, 215.
Ferguson, R. S. (1930). *Amer. J. Surg.*, 9, 507.
Hermitte, L. C. D., and Ellis, F. (1947). *Recent Advances in Clinical Pathology*, 1st ed., p. 324. London; Churchill.
Iversen, P., and Roholm, K. (1939). *Acta. med. scand.*, 102, 1.
Kirschner (1934). *Zbl. chir.*, 61, 2225.
— (1935). *Schweiz. med. Wschr.*, 65, 28.
Martin, H. E., and Ellis, E. B. (1930). *Ann. Surg.*, 13, 169.

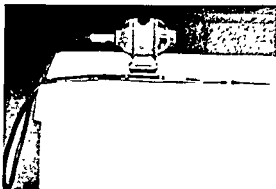
Special search for fragments of tissue

syringe and off the end of the piston with the tip of a scalpel will be profitable. A number of small fragments can often be scraped up to the mouth of the syringe, and then expelled into the fixative. This may be necessary even after the syringe has been rinsed out with fixative.

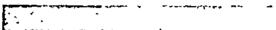
(2) Method II—drilling and aspiration

Trephine-type needle

The principles of technique are essentially the same as those in the first method, but the needle is of trephine type, is introduced with the help of a suitable trocar (Fig. 172), and when down to the growth the trocar is removed and the needle is attached directly to a dental drilling machine so that the needle revolves as it is pushed into the lesion. Ellis has so far used an ordinary treadle dental drilling machine, but is of the opinion that a small portable electric motor as used and illustrated by Christiansen (1940) (Fig. 173(a)) would render the operation easier and allow of simpler speed regulation. It should be noted that suction is unnecessary during manipulation of the needle within the lesion, thus affording the operator greater control than in the first method. When it is time to withdraw the needle for the cutting process, it is disconnected from the chuck of the drilling machine and the syringe is connected to provide suction during the cutting process (Fig. 173(b)).



(*a*)



(*b*)

FIG. 173.—(*a*) Portable electric motor with cable and chuck used in drill biopsies by Christiansen (by kind permission). (Now exclusively used by Ellis.) (*b*) Syringe for attachment during cutting process.

The results with this method, in the hands of Ellis, have been so much more satisfactory that he now uses it exclusively. The advantages over the first method are:

(1) As already stated, greater control is afforded to the operator.

(2) A greater number of positive results secured, as shown in the following table.

(3) The piece of tissue obtained is much larger, keeps its structure better and is more susceptible of confident detailed interpretation.

(4) While it can be used in all types of lesions, it is more suitable for hard lesions (for example, fibromas, chondromas, chondrosarcomas, osteogenic sarcomas of sclerotic type and metastatic cancer of the vertebrae and other bones). For lesions within bone with a hard cortex it is advisable to introduce the aspiration needle through a hole in the cortex previously made with a bone drill worked by hand.

GLANDERS

By G. H. WOOLDRIDGE, F.R.C.V.S., M.R.I.A.
EMERITUS PROFESSOR OF VETERINARY MEDICINE, ROYAL VETERINARY COLLEGE, LONDON
AND
SIR ERNEST ROCK CARLING, F.R.C.S., F.R.C.P.
CONSULTING SURGEON, WESTMINSTER HOSPITAL

1. GLANDERS IN ANIMALS

(1) Definition

168.] Glanders is an infectious disease, mainly of solipeds (horses, asses and mules), characterized by nodular lesions in the lungs and certain other internal organs (for example, the liver) and by ulcerative lesions of the respiratory mucous membrane and of the skin (farcy). Carnivora are susceptible to a lesser degree. Glanders has been met with affecting wild carnivora in zoological gardens and is believed to be due to feeding the animals with raw, infected horse-flesh. Goats and sheep are still less susceptible, and cattle and swine are immune. Man is also susceptible, and cases of human infection have occurred, usually as a result of handling infected animals and also in laboratory work. *Characteristics*

(2) History

Glanders has been known since ancient times, and until the end of the last century was widespread amongst equines in all parts of the world where horses existed in numbers, particularly in large towns. Until the introduction of mallein in 1890, control was handicapped by the inability to diagnose early clinical or pre-clinical cases, many of which were highly infective. Thanks to this agent, however, cases of glanders have now declined to almost negligible numbers, and a case has not been recorded in Great Britain since 1928. Glanders is scheduled in Great Britain under the Contagious Diseases (Animals) Act, and its existence or suspicion must be reported immediately to the Ministry of Agriculture.

Martin, H. E., and Ellis, E. B. (1934). *Surg. Gynec. Obstet.*, 59, 578.
— — (1940). *Treatment of Cancer and Allied Diseases*, Vol. 1, p. 72. New York; Hoeber.
Sayago, C. (1942). *Amer. J. Roentgenol.*, 48, 78.
Stewart, F. W. (1933). *Amer. J. Path.*, 9, 801.
Valls, J., Ottolenghi, C. E., and Schajowicz, F. (1942). *La Biopsia por Aspiracion en el Diagnostico de las Lesiones Oseas.* Buenos Aires; Libreria y Editorial "El Ateneo".
Wrenn, F., and Feder, J. M. (1942). *Surgery*, 11, 456.
[References to other titles are given under Gland-Puncture and Aspiration Biopsy in the Index Volume.]

noticeably inside the thigh, the superficial lymphatic vessels are distended, giving rise to the so-called "farcy cords" or "farcy pipes". Small tumour-like enlargements, varying in size from a pea to a walnut, appear on the skin in various parts of the body; these are the so-called "farcy buds" and may be single or multiple and sometimes occur in chains along the course of lymphatic vessels of the limbs, chest wall, face or elsewhere. At first hard, they tend to soften in the centre and burst, emitting a little blood-tinged pus followed by a characteristic, but not copious, discharge of oily liquid. The ulcer-like lesion has a red base with a yellowish pouting edge and has little tendency to heal.

(5) *Incubation period*

The period of incubation of glanders in horses in naturally occurring cases depends on the virulence of the organism and on the channel of infection. When due to contaminated food or water there may be a period of anything from 1 to 3 months or even longer before the appearance of clinical symptoms. In experimental cases, in which infection is by inoculation or by the administration *per os* of large doses of culture, the period may be from 3 to 5 days. *Determining factors*

(6) *Clinical picture*

In the majority of cases glanders is of a chronic nature; its development is slow and insidious. Usually, the first indication of ill health is a general unthriftiness with some loss of body-weight and possibly slightly increased urination and a dryish appearance of the coat. If the temperature is taken methodically at this time it may be found to fluctuate around 102·5° F. but still without marked indication of any serious illness. Then more pronounced polyuria and wasting of the body develop and a marked dullness at work and an occasional cough are noticed. This is usually followed by a nasal discharge, often unilateral except in acute cases, muco-purulent and viscid, and sometimes streaked with blood. In acute cases the discharge is likely to be unilateral, and more copious and purulent in nature. The amount of discharge does not appear to bear any relationship to the extent of the ulceration of the nasal mucosa, and generally the odour is not offensive. When present in the lower part of the nasal septum, ulcers may easily be seen. They are circular—unless several have coalesced—with dark-red bases and raised clean-cut borders. Stellate cicatrices may sometimes be seen, indicating healed ulcers. In the worst cases the whole mucous membrane of the nasal passages may be an almost continuous ulcerating surface and perforation occasionally occurs. The submaxillary lymphatic glands are almost invariably enlarged, usually unilaterally, though in severe cases both sides are affected. An affected gland may attain half the size of a hen's egg, is hard, cold and painless and well circumscribed; it hardly ever suppurates. It is usually adherent to the inner side of the joint. (Old London stablemen, for some unexplained reason, used to call this condition a "jug".) *Chronic nature* *Temperature* *Nasal infection*

Oedema of the limbs occurs in many cases and may pass away after a few days. It may be recurrent, however, and is then likely to result in chronic thickening. Cutaneous glanders with the appearance of farcy cords and farcy buds often develops in such cases, especially inside the thighs and forearms. In a general way the intestinal tract is not involved, but occasionally *Oedema*

(3) Aetiology

Causal organism

Glanders is caused by *Pfeifferella mallei* (*B. mallei*), a short rod with rounded ends which usually occurs as a single element or occasionally in pairs or short chains. It is from 3μ to 6μ in length and from $0{\cdot}3\mu$ to $0{\cdot}4\mu$ in breadth, is non-motile and does not sporulate. It is essentially a tissue parasite with a predilection for the lymphatic system and is recoverable from pus, discharges from ulcers and nasal mucous membrane and from infected tissue. The organism stains readily with watery solutions of the aniline dyes, especially those containing a mordant such as Löffler's alkaline methylene blue, but is Gram-negative.

Route of infection

Infection may occur by ingestion, by inhalation or by inoculation; the principal channel of infection in horses is the alimentary tract and the common media for communicating it are mangers, street watering-troughs, nose-bags, grooming utensils (for example, sponges), bridles and litter. Infection by inhalation is probably not so common as might be suggested by the great frequency of pulmonary lesions. M'Fadyean (1904) showed that extensive pulmonary lesions with few or no abdominal lesions may result from ingestion of the organism. The frequency of small wounds about the lower end of the limbs affords easy access to infective material in the litter and bedding, and small abrasions about the body readily permit infection from contaminated grooming utensils or harness.

(4) Lesions

The commonest lesions in the horse are found in the lungs as firm nodules embedded in otherwise apparently healthy tissue, varying in size from a millet seed to a small hazel-nut and numbering from half a dozen to several hundreds. On section, recent lesions are seen to be greyish-white in colour in the centre and surrounded by a fine hyperaemic zone. In older lesions the nodules are surrounded by a fibrous capsule with a granular centre which may become gritty by the deposition of calcareous salts. The associated lymphatic glands, bronchial and tracheal, are usually somewhat enlarged and indurated but with very little congestion and may contain small nodules. Ulcerative lesions may be found in the trachea and larynx and, more commonly, on the nasal septum, with enlargement of the submaxillary lymphatic glands. In some cases the turbinate bones and even the frontal sinus may show similar ulcers. The nasal ulcers commence as small nodules in the mucosa, the centre point disintegrates and is thrown off, leaving a characteristic ulcer as though a spot of mucous membrane had been cleanly punched out, but with a somewhat hyperaemic and raised margin; the nasal discharges in such cases are usually rich in *Pf. mallei*. In some old-standing cases the nasal septum may show perforations and in others ulcers may have healed and left rather characteristic stellate cicatrices. Lesions may be met with in abdominal organs —liver, spleen and kidneys—and in the testicles and lymphatic glands. The lesions are nodular and somewhat similar to the pulmonary foci. Ulcerations of various parts of the intestines are sometimes seen.

Histology

Cutaneous glanders

Cutaneous glanders, or farcy, takes the form of a diffuse subacute or chronic lymphangitis and lymphadenitis which may occur anywhere on the surface, but most frequently affects one or both hind limbs. The leg is somewhat swollen from the pastern to just above the hock, and above that point, more

the reaction, almost closing the eye. A positive reaction is usually accompanied by a rise of temperature of one or two degrees, with increased pulse rate and respiration rate, shivering and some inappetence.

(8) Differential diagnosis

Several conditions may give rise to strong suspicions of glanders, such as enlarged submaxillary lymphatic glands due to local mouth lesions, strangles in young horses, epizootic lymphangitis, and others. Strangles is usually met with in young horses and is an acute infection associated with nasal discharges and with abscesses of the submaxillary glands. Pus from these sources usually teems with chains of streptococci. *Signs*

Epizootic lymphangitis

This disease is not existent in Great Britain at the present time—the last confirmed case occurred in 1906. The lesions closely resemble those of cutaneous glanders in farcy, with small abscesses (buds) along the course of the lymphatics of the limbs, head or other areas of the skin. It is a comparatively benign affection, is rarely associated with enlargement of lymphatic glands and does not provoke a reaction to mallein. Moreover, the causal organism, the cryptococcus of Rivolta, is easily demonstrable in pus from fresh skin lesions.

(9) Control of glanders

Glanders is included in the schedule of notifiable diseases under the Contagious Diseases (Animals) Act, and its existence or suspicion must be reported at once to the Ministry of Agriculture. It is administered under the Glanders and Farcy Order, 1930. Under this order all clinically affected animals and all those reacting to the mallein test are slaughtered. All contacts are detained, tested with mallein and dealt with accordingly. Other provisions of the order deal with post-mortem examinations, disposal of carcasses, destruction of infected articles, fodder and litter, and the cleansing and disinfection of premises, utensils, vehicles, mangers, feeding-troughs, watering-troughs and any other things used for or about infected animals. *Notifiable disease*

2. GLANDERS IN MAN

With the disappearance of glanders among solipeds in Great Britain, infection in man, which apart from laboratory accidents results from direct contact with affected animals, has become exceedingly rare. No cases have been reported since a doubtful one in 1938. In the 25 years ending in 1945 six cases were notified.

(1) Aetiology

Infection occurs through the abraded skin or hair follicles, or via the nasopharynx. The course may be acute or chronic. There may be long periods of complete quiescence followed by an acute outbreak which may be fatal. *Route of infection*

The site of infection on a skin surface may be unobserved and overt evidence may not appear for weeks or months, or there may be a papular eruption, a local swelling which slowly breaks down, or an ulcerative lesion with attendant lymphangitis and adenitis. When the mucosae are the seat of infection a sero-purulent discharge, which becomes sanguineous, is an early sign. *First signs*

No tissue or organ in the body is exempt from invasion. Every lesion *Pathology*

ulceration of the bowel occurs with resulting diarrhoea but with nothing suggestive of glanders.

Acute type

An acute type of glanders may result from the breaking up of a chronic lesion which has existed for years, and in some of these cases the blood stream is invaded and an intense pneumonia is set up. The horse shows very marked respiratory distress, the mucous membranes are very injected, the nasal discharges are greatly increased and there is a full bounding pulse. The temperature is between 105° F. and 107° F. and appetite is completely lost. There is often a sudden appearance of numerous small farcy buds and swelling of the legs. The course in such cases is very rapid and is fatal within 4 or 5 days.

Notwithstanding the marked symptoms of glanders indicated, this disease may exist in horses in good bodily condition not giving any indication that they are affected with the disease. Such cases are only discovered as the result of a general mallein test applied after the discovery of a clinical case in a stud of working horses. There is good ground for believing that cases of this sort may be infective, and may have been responsible for various outbreaks in stables in which the disease was not known to exist.

(7) Diagnosis

Microscopic confirmation

Clinical glanders may be diagnosed with a reasonable degree of certainty from the external lesions. Microscopic examination of suspicious discharges may confirm the diagnosis, but inability to demonstrate the specific organism does not justify a negative diagnosis. Cultural methods may be resorted to if uncontaminated material is available, or a male guinea-pig may be injected intraperitoneally, with the production of a glanderous orchitis in positive cases in from 4 to 8 days. An agglutination test may also be resorted to, as also may be the precipitin test or the complement fixation test.

Diagnosis by means of mallein

Mallein test

This is probably the best procedure in pre-clinical and doubtful cases. Mallein is a glycerinated extract of *Pf. mallei* prepared from cultures in glycerin broth, sterilized in the autoclave and passed through a Berkefeld filter. There are three methods of applying the mallein test, namely : the ophthalmic test, the subcutaneous test and the intra-dermo-palpebral test. The second of these tests was the one used with such excellent results in the main campaign for the eradication of glanders, but it is now largely superseded by the intra-dermo-palpebral test which is extremely reliable and more easily carried out, especially if considerable numbers of horses have to be tested. For this latter test a concentrated mallein is used. The dose is 0·1 cubic centimetre and it is injected intradermally into the lower lid of one eye from ¼ to ½ inch below the margin, the point of the needle at the moment of injection being about half-way between the inner and outer canthi. In negative cases nothing more than very slight oedema of the lid results from the injection; this, as a rule, disappears in about 24 hours. In animals with glanders there is usually a marked reaction consisting of a more or less tense and very painful swelling of the injected eyelid commencing 5 or 6 hours after the injection and increasing in extent and intensity for up to about 48 hours. This may persist for 72 hours or so and then slowly subside. A fairly severe conjunctivitis with a muco-purulent discharge from the inner canthus accompanies the swelling. In many cases the whole orbital area becomes oedematous during

Marked reaction

the reaction, almost closing the eye. A positive reaction is usually accompanied by a rise of temperature of one or two degrees, with increased pulse rate and respiration rate, shivering and some inappetence.

(8) *Differential diagnosis*

Several conditions may give rise to strong suspicions of glanders, such as enlarged submaxillary lymphatic glands due to local mouth lesions, strangles in young horses, epizootic lymphangitis, and others. Strangles is usually met with in young horses and is an acute infection associated with nasal discharges and with abscesses of the submaxillary glands. Pus from these sources usually teems with chains of streptococci. *Signs*

Epizootic lymphangitis

This disease is not existent in Great Britain at the present time—the last confirmed case occurred in 1906. The lesions closely resemble those of cutaneous glanders in farcy, with small abscesses (buds) along the course of the lymphatics of the limbs, head or other areas of the skin. It is a comparatively benign affection, is rarely associated with enlargement of lymphatic glands and does not provoke a reaction to mallein. Moreover, the causal organism, the cryptococcus of Rivolta, is easily demonstrable in pus from fresh skin lesions.

(9) Control of glanders

Glanders is included in the schedule of notifiable diseases under the Contagious Diseases (Animals) Act, and its existence or suspicion must be reported at once to the Ministry of Agriculture. It is administered under the Glanders and Farcy Order, 1930. *Under this order all clinically affected animals* and all those reacting to the mallein test are slaughtered. All contacts are detained, tested with mallein and dealt with accordingly. Other provisions of the order deal with post-mortem examinations, disposal of carcasses, destruction of infected articles, fodder and litter, and the cleansing and disinfection of premises, utensils, vehicles, mangers, feeding-troughs, watering-troughs and any other things used for or about infected animals. *Notifiable disease*

2. GLANDERS IN MAN

With the disappearance of glanders among solipeds in Great Britain, infection in man, which apart from laboratory accidents results from direct contact with affected animals, has become exceedingly rare. No cases have been reported since a doubtful one in 1938. In the 25 years ending in 1945 six cases were notified.

(1) Aetiology

Infection occurs through the abraded skin or hair follicles, or via the nasopharynx. The course may be acute or chronic. There may be long periods of complete quiescence followed by an acute outbreak which may be fatal. *Route of infection*

The site of infection on a skin surface may be unobserved and overt evidence may not appear for weeks or months, or there may be a papular eruption, a local swelling which slowly breaks down, or an ulcerative lesion with attendant lymphangitis *and adenitis. When the mucosae are the seat of infection* a sero-purulent discharge, which becomes sanguineous, is an early sign. *First signs*

No tissue or organ in the body is exempt from invasion. Every lesion *Pathology*

characteristic of other granulomas may be met with; there is no means of precise histological differentiation.

Clinical course

The disease may run a very slow course, with long intervals of apparent health interrupted by the appearance of some unexplained eruption, abscess, thrombosis or osteomyelitis. On the other hand, the pattern may be that of a pyaemia, with localization in the pleura, lungs, meninges, joints, renal or intestinal tracts, with fever, rigors and delirium leading rapidly to death.

(2) Diagnosis

Occupation

In a disease with protean manifestations, the most important diagnostic point is that the patient's occupation entails contact with horses. Almost all recorded cases have been in grooms, cavalrymen, blacksmiths and veterinary surgeons. Otherwise the diagnosis may be confused with that of syphilis, tuberculosis, actinomycosis or leprosy. The acute form may rouse suspicion of typhus, typhoid, pneumonia, influenza or even of acute rheumatism.

The mallein test gives rise, after inoculation, to a fever of 104° F. or 105° F. which returns to normal in about 48 hours. Straus's test, by inoculation of suspected material into male guinea-pigs, gives as a positive result an acute orchitis. It is reliable but may not permit an opinion within as much as 14 days.

Blood cultures are seldom positive until shortly before death. Agglutination and complement fixation tests have been employed.

(3) Treatment

Beyond the usual surgical measures for local lesions, nothing specific can claim much success. Vaccines, injections of bovine or naturally immune sera have been suggested, and repeated injections of mallein have been used with a claim of success. Large doses of penicillin should be administered. While there is as yet little, if any, evidence that this antibiotic is potent in glanders, it has been used successfully in combination with sulphonamides for melioidosis (Harries and his colleagues, 1948).

Prognosis

Prognosis should be extremely guarded. The acute form of glanders is deadly, and the chronic type is subject to relapse after long intervals and to the development of generalized disease with a fatal issue.

BIBLIOGRAPHY AND REFERENCES

Bernstein, J. M., and Carling, E. R. (1909). *Brit. med. J.*, **1**, 319.
Gaiger, S. H. (1913). *J. comp. Path.*, **26**, 223.
— (1916). *Ibid.*, **29**, 26.
Harries, E. J., Louis, A. A. G., Wearing, J. W. B., and Dowling, E. J. (1948). *Lancet*, **1**, 363.
Herold, A. A., and Erickson, C. B. (1938). *Sth. med. J.*, **31**, 1022.
Hunting, W. (1906). *Vet. J.*, **13**, 64.
— (1908). *Glanders: A Clinical Treatise*, p. 90. London; H. & W. Brown.
Johnstone, E. M., and Young, C. W. (1917). *Chin. med. J.*, **31**, 1.
M'Fadyean, J. (1904). *J. comp. Path.*, **17**, 295.
Rainsford, S. G. (1932). *Brit. med. J.*, **2**, 55.
Straus, I. (1889). *Arch. Méd. exp.*, **1**, 460, 489.
Tang, F. F., Liu, S. H., and Kau, L. S. (1935). *Chin. med. J.*, **49**, 248.
[References to other titles are given under Glanders in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 555.]

GLAUCOMA

By R. AFFLECK GREEVES, F.R.C.S.
Consulting Surgeon, Moorfields, Westminster and Central Eye Hospital; Consulting Ophthalmic Surgeon, Middlesex Hospital, London

1. DEFINITION

169.] The condition known as glaucoma is established when the intra-ocular pressure is raised above normal limits; in other words the eye becomes harder than normal.

2. PHYSIOLOGY

The eye possesses a certain intra-ocular pressure which corresponds closely to the pressure in the intra-ocular veins and is determined by the amount of aqueous humour present in the eye. This fluid is constantly renewed from the capillary vessels of the ciliary body, while the excess is drained away through channels situated at the angle of the anterior chamber, and theoretically glaucoma might arise through excess of production of fluid, diminution of its excretion or both. Such evidence as we possess goes to show that if the drainage channels are functioning normally a rise of intra-ocular pressure does not occur. In other words glaucoma can be ascribed in most cases to a failure of the drainage system. The actual method of production of this fluid has not yet been definitely determined. *Failure of drainage system*

Persistent increase of intra-ocular pressure leads eventually to blindness, because, whereas the outer coat of the eye is mainly rigid and inelastic, there is one weak spot. This is the lamina cribrosa, a delicate fenestrated fibrous membrane, through which the optic nerve fibres pass out of the eye. *Harmful effects of increase of intra-ocular pressure*

This membrane yields to even slight degrees of increased intra-ocular pressure, and so the nerve fibres become pressed upon, stretched, and ultimately atrophic, and the greater the increase of pressure the more rapidly does this atrophic process proceed. Hence, once a diagnosis of glaucoma is made, some measures must be taken to restore the intra-ocular pressure to normal limits, and the greater the pressure the more urgent is the need.

3. AETIOLOGY

Primary and secondary glaucoma

Interference with drainage of fluid from the eye may eventuate from a variety of causes; it may be a complication of some other pathological condition, or may constitute the primary disease. The former type is known as secondary glaucoma, and the latter as primary glaucoma. In the former case the interference with drainage is readily explicable by an alteration in the local conditions necessarily associated with a particular disease or lesion, whereas in the latter the mechanism of such interference is to some extent still a matter of theory.

4. PRIMARY GLAUCOMA

Cases of primary glaucoma can be divided clinically into two distinct varieties, one which exhibits, in acute or subacute form, certain classical signs and

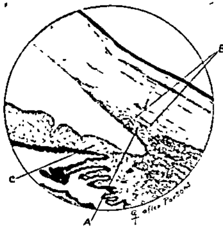


FIG. 174.—Normal angle of anterior chamber showing (A) the spongy tissue of the ligamentum pectinatum through which the aqueous drains into (B) Schlemm's canal, and (C) the root of the iris.

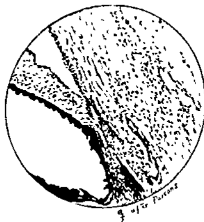


FIG. 175.—Angle of the anterior chamber in a glaucomatous eye. The root of the iris is in contact with the ligamentum pectinatum, thus precluding all drainage.

symptoms apart from loss of sight, and one in which the patient experiences nothing but a slow and gradual loss of visual field and failure of vision with ultimate blindness.

(1) Acute congestive glaucoma

To the former belongs acute congestive glaucoma, not only the most severe manifestation of the disease, but that which is in most urgent need of immediate treatment.

(*a*) *Pathology*

Acute glaucoma is a disease of middle and old age. It occurs in hypermetropic eyes; such eyes are smaller than normal and consequently possess shallow anterior chambers, so constructed that little room is present between the angle formed by the root of the iris and the corneo-scleral periphery, at the apex of which the drainage channels are situated (Figs. 174 and 175).

Also the lens gradually increases in size during life, further diminishing the depth of the anterior chamber, and this is believed to have a bearing on the age incidence of this type of glaucoma.

When these predisposing conditions are present, so that the peripheral part of the iris lies extremely close to the sclero-corneal junction, only a slight degree of congestion of the blood-vessels of the highly vascular iris and ciliary body would be sufficient to cause apposition of iris root and cornea, in which case the exit of fluid from the eye would be effectively blocked.

(*b*) *Signs and symptoms*

The acute attack

The attack is sudden in onset, the patient experiencing severe ocular pain radiating to the brow and temporal region, usually accompanied by vomiting, the latter symptom being very characteristic of the early stage of the disease. There is also a measure of general shock and collapse. On examination, the eyeball is intensely congested and some oedema of the eyelids may be present.

The cornea is hazy, showing a characteristic "ground-glass" appearance. The pupil is inactive to light, dilated and, as a rule, not circular in shape but oval, the long axis of the oval being vertical, with dilatation most marked in the upper segment. The anterior chamber is very shallow; in other words, the circumference of the iris, dimly seen owing to the loss of transparency of the cornea, appears to be almost in contact with the posterior corneal surface.

When the tension of the eyeball is estimated by digital pressure, the globe is felt to be hard and unyielding.

Fundus examination is not possible, because of the corneal haze.

(*c*) *Differential diagnosis*

The following two conditions in which sudden acute ocular pain occurs are those most likely to be confused with an acute congestive glaucoma.

Tension not raised

(i) *Acute iritis* is accompanied by severe circum-orbital neuralgia, with intense ocular congestion, and haziness of the cornea. Vomiting is not a feature of this disease, the anterior chamber is not shallow, nor is the intra-ocular tension raised; the latter point may be difficult to determine owing to extreme tenderness of the eyeball to digital pressure.

State of the pupil

By far the most readily recognizable sign in the differential diagnosis is the state of the pupil, which, although inactive to light, is contracted. Careful examination with magnification may also show adhesions of the pupillary margin to the surface of the lens.

(ii) *Corneal ulceration* is also attended with acute pain of a neuralgic character; its onset may be sudden, and the eyeball is intensely congested; the pain is, however, of a more local and stabbing character, a feeling as though a sharp foreign body were in the eye, and very profuse lacrimation is a most characteristic sign.

Instillation of cocaine

The pupil is unaltered in size or smaller than normal and is active to light; the anterior chamber is normal in depth and the intra-ocular tension normal. Instillation of a 4 per cent solution of cocaine causes rapid abatement of the pain, whereas this drug is not effective in acute glaucoma and only slightly so in acute iritis.

Acute conjunctivitis also shows extreme ocular congestion, usually with some oedema of the eyelids, but in this case there is a profuse discharge of

muco-pus, the pupil and anterior chamber are unaltered and the pain is much less severe.

(d) *Non-operative treatment of acute glaucoma*

Use of eserine

Immediately the diagnosis is made, a solution of eserine, 1 per cent in castor oil, should be dropped into the eye at half-hourly intervals. Eserine takes effect by stimulating the sphincter pupillae and so causing reopening of the anterior chamber angle by dragging the iris root away from the sclero-corneal inner surface. Adhesions, in the first instance exudative, and later organized, are readily and quickly established between the iris root and the cornea, and if this process has begun, eserine may partially or completely fail in its purpose. Hence the importance of instilling eserine at the earliest possible moment.

Heat

Leech

Heat should be applied to the eye through the closed eyelids, either by persistent sponging by the patient himself, with water as hot as can be borne by the skin or, if the patient is too ill to do this, by hot fomentations constantly changed by a nurse. A leech, if obtainable, should be applied to the temple, just external to the bony orbital margin.

The patient should be kept in bed, and an effective aperient as well as a sedative should be administered. This latter may take the form of ⅙ grain of morphine if the pain is very severe and if no contra-indication is present. The earliest recognizable local evidence of reduction of intra-ocular tension by these means is a lessening of the size of the pupil.

Emergency operation

This contraction takes place slowly, but if it should continue so that the pupil becomes small and circular, the prognosis as regards complete temporary relief of tension is favourable. Unfortunately, however, this relief is often only partial, the pupil, although smaller, remaining fixed and semi-dilated, while the tension is only partially lowered. Cases in which no response to treatment is evident within a few hours must be subjected to an emergency operation, and this also applies to those in whom the response remains partial, although in the latter cases the matter is less urgent.

If relief is complete, as shown by a pin-point pupil and lowered tension, operative measures should be delayed until all ocular congestion has disappeared, ½ per cent of eserine sulphate solution being meanwhile instilled three times a day.

An operation must be undertaken, however, at an early date, otherwise there is grave danger of a fresh attack, against which treatment by means of eserine drops is by no means a sure safeguard.

(e) *Operative treatment of acute glaucoma*

(i) *Iridectomy.*—If too much time has not been lost, removal of a fifth of the circumference of the iris by iridectomy is sufficient to reopen the closed drainage angle and to prevent further attacks in future. This iridectomy must be a peripheral one.

Iridectomy for glaucoma is one of the most difficult of all ophthalmic operations to perform, and requires exceptionally skilful technique.

Its peculiar difficulty lies mainly in the fact that, when making the section, the knife must necessarily be passed between cornea and lens, across an almost non-existent anterior chamber.

Damage to the lens capsule would inevitably cause a traumatic cataract and introduce grave complications. This operation should not, therefore, on any account be undertaken except by a surgeon of experience in ophthalmic surgery.

(ii) *Posterior sclerotomy.*—There is, however, an operation of a simpler type which is sometimes adopted even by experienced ophthalmic surgeons as a preliminary measure, in order to deepen the anterior chamber and lower the tension in preparation for a subsequent iridectomy. The relief afforded is not permanent, but persists for at least 24 hours, and may possibly last even for several days; this operation is comparatively easy to perform, and fraught with few dangerous complications. It would serve as a temporary measure of relief in cases of emergency, until more expert assistance could be obtained. The operation is known as posterior sclerotomy, and is performed as follows.

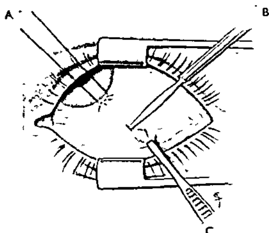


Fig. 176.—Illustrating the operation of posterior sclerotomy. A = retraction suture; B = the Graefe knife; C = forceps.

Technique

Owing to the extreme tenderness of the eyeball, a general anaesthetic must be given. Pentothal Sodium is eminently suitable, as the operation is of short duration. The site selected for the operation—because easiest of access—is the lower and outer anterior quadrant of the globe, between the external and inferior recti muscles.

The eyeball is rotated upwards and inwards by means of fixation forceps, and a long silk suture is inserted through the conjunctiva close to the limbus at its lower and outer part. The two ends of the suture are held by an assistant, who, by exerting traction on them, holds the eye in the desired rotated position.

The surgeon then stretches the loose ocular conjunctiva laterally by means of fixation forceps applied in the down and out position, and plunges a Graefe knife through conjunctiva, sclerotic, and choroid into the vitreous chamber to a depth of 3 millimetres (Fig. 176). This incision is made meridionally with the edge of the knife pointing towards the cornea, at a distance of 15 millimetres from its margin, and should measure about 5 millimetres; before withdrawal, the knife edge is turned sharply at right angles to the original incision. The outlying conjunctiva is then allowed to slide back into place, so that the scleral incision is covered because it no longer coincides with the hole in the conjunctiva.

A small amount of vitreous humour escapes through the L-shaped scleral incision, causing some bulging of the overlying conjunctiva. After the operation, the eye is covered with a pad and bandage, but 2-hourly instillations of 1 per cent oily eserine must be maintained, except during sleep.

(2) Subacute and intermittent glaucoma

Subacute attacks

In addition to cases of acute fulminating glaucoma, as just described, others of a subacute type occur, in which similar signs and symptoms appear, but to a much lesser degree. The pain experienced is dull and neuralgic in character, ocular congestion is slight, the cornea is a little steamy, and the pupil is partially dilated and sluggish. If the fundus is visible, retinal arterial pulsation may be seen. Such cases respond more readily to treatment by eserine drops and heat, but again, an ultimate operation is imperative.

Intermittent attacks

Patients are also met with in whom transient intermittent attacks of slightly raised tension occur, alternating with periods in which the tension is normal. In the course of these attacks the sight of the affected eye becomes misty, and there is often some circum-orbital neuralgia; on looking at a source of light in a badly lighted room or street, the patient sees a circular halo, which comprises all the colours of the rainbow, surrounding the light, and at some little distance from it.

"Glaucomatous haloes"

These are the notorious "glaucomatous haloes", and a history given by any patient of seeing rainbow colours round lights should always be regarded with the utmost suspicion, for although rainbow rings round lights can arise in other circumstances, an attack of raised intra-ocular tension is by far the commonest cause of such a manifestation. It is due to the separation of light into its component wave-lengths through the agency of the oedematous cornea. Pending operative intervention, periodic instillations of eserine, in sufficient strength to keep the pupil contracted, should be instituted.

(3) Glaucoma simplex

The other variety of primary glaucoma, known as glaucoma simplex, is actually the commonest met with in practice, but it is slow and insidious in onset, and does not demand emergency measures. Its only symptoms are failing vision coupled with a characteristic loss of visual field; it is unattended by pain or haloes and may reach an advanced stage without the patient being aware that anything is wrong. Indeed its presence is often first discovered by an ophthalmic surgeon who, in the course of a routine examination, observes cupping and atrophy of the optic disc.

Painless loss of vision

Its pathology, to some extent obscure, obviously differs from that of the acute and subacute varieties, and the operations necessarily undertaken for its relief involve the establishment of a permanent fistula as a new drainage channel.

Establishment of permanent fistula

To achieve this, a variety of operative procedures have been devised by different ophthalmic surgeons, but the ultimate object of all of them is to establish what is known as a "filtering scar" through which the aqueous humour can percolate from the anterior chamber into the subconjunctival tissue.

These various operations include the Lagrange operation (the first of its kind to be adopted), corneo-scleral trephining, iridencleisis, Herbert's sclerotomy, as well as others, and ophthalmic surgeons differ widely in their opinions as to the relative merits of each.

These are not emergency operations; they require skilled technique and, like the operation of iridectomy for acute glaucoma, should never be undertaken except by a fully trained ophthalmic surgeon.

5. SECONDARY GLAUCOMA

Secondary glaucoma, or raised intra-ocular tension, existing as a complication of some other disease of the eye, produces the same disastrous effects on sight as are found in the primary varieties, and must be relieved if inevitable blindness is to be prevented. If acute, its signs and symptoms may resemble closely those of acute primary glaucoma.

In the main, however, such measures as are taken for its relief are directed primarily towards the treatment of the condition which is at the root of the trouble.

[References to other titles are given under Glaucoma in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 5, p. 575.]

GLOMUS TUMOURS

By W. A. MACKEY, F.R.F.P.S., F.R.C.S.Ed.
Assistant to the Professor of Surgery, University of Glasgow; Visiting and Consulting Surgeon, Corporation of Glasgow

1. DEFINITION

(*Synonyms.*—Glomangioma, angioneuromyoma, tumour of neuro-myo-arterial glomus)

170.] The glomus tumour is an angioma of specific histology which tends to produce a striking and characteristic painful symptom-complex. The parent organ is the glomus.

2. ANATOMY AND PHYSIOLOGY

Glomus cells

The glomus (pl. glomera) is a convoluted arteriole communicating directly with a venule. Beneath the intima is a layer or layers of cuboidal cells, apparently modified smooth-muscle cells to which the name "glomus cells" has been given. There is a rich perivascular nervous network (Masson, 1924; Popoff, 1934). It is found principally in the skin and most abundantly in the skin of the more distal parts of the limbs and in the nail-beds. The glomera appear to act as arterio-venous shunts and, when open, to permit large amounts of arterial blood to circulate rapidly immediately beneath the skin. Their function is almost certainly thermo-regulatory. They are most richly furnished to those parts of the skin which show the most extreme

Thermo-regulatory function



Fig. 177.—Low-power view of typical glomangioma. The peripheral blood spaces, at the lower margin of the field, are well defined, and show a thick tunic of glomus cells. The more central portion of the tumour has a cavernous arrangement, with large irregular blood spaces. Here the glomus-cell layer is thinner. (× 50.) (*Brit. J. Surg.*)

thermo-regulatory variations of surface temperature. Similar structures are known to occur in cavernous tissue and in the glomus coccygeum. They are



FIG. 178.—High-power view showing typical arrangement of layered glomus cells beneath the intima of a cavernous space. (× 100.) (*Brit. med. J.*)

probably not normal findings elsewhere.

3. PATHOLOGY

Size and consistency

The glomus tumour is a simple tumour, generally small, ranging in size from a few millimetres to perhaps 1·5 centimetres. Grossly it may appear fairly solid and of rather cartilaginous consistence, whereas at the other end of the scale it may assume a cavernous form. The more compact growths occur in dense tissue such as the nail-bed; the cavernous form occurs in loose subcutaneous tissue. The tumour is encapsulated, attached only by a tenuous pedicle to the surrounding tissues from which it can be readily shelled out. Histologically the one characteristic feature is the glomus cell. The general structure may be organoid or histoid. That is to say, it may have

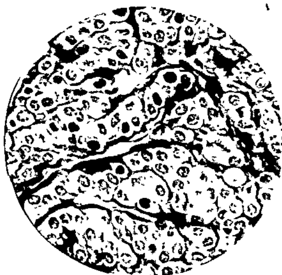


FIG. 179.—Masson's trichrome stain. Paucivascular form of glomus tumour. Sheets and solid masses of cuboidal glomus cells and scanty, cleft-like blood spaces. (× 500.) (*Brit. med. J.*)

Characteristic histology

an obviously angiomatous structure, generally cavernous, and be identified as glomangioma by the presence beneath the intima of layers of glomus cells (Figs. 177 and 178), or, on the other hand, the picture may be one of sheets of glomus cells traversed by quite small blood spaces lined by endothelium (Figs. 179 and 180). The anatomical incidence of glomus tumour is roughly proportional to the normal distribution of the glomera, and the limbs are principally affected.



FIG. 180.—Thin-walled blood spaces are separated by wide sheets of glomus cells. In the centre of the field a gradual transition is seen between typical cuboidal forms of the latter and fusiform cells which may well be poorly-developed smooth-muscle fibres. (× 200.) (*Brit. J. Surg.*)

4. DISTRIBUTION

Occurs mainly in limbs

In the upper extremity the tumour is met most frequently in the hands, and commonly in the nail-beds; in the lower limb acral distribution is not so marked. It may, however, occur in any part of the skin, and it has been described in skeletal muscle and even the omentum. It is usually a single tumour but multiple lesions have been recorded.

5. CLINICAL FEATURES

Paroxysmal pain

Protective mannerisms

Radiation

The most striking clinical feature of the glomus tumour is pain, which may be agonizing, variously described as bursting, burning or stretching. It occurs in paroxysms, often brought on by trauma, pressure, or even by the lightest touch, such as by clothing, or by change of temperature, as produced by the warmth of the bed. The patient will often develop protective mannerisms and modify his entire mode of life to avoid stimulation of the tumour. The pain originates in the tumour but tends, as attacks go on, to radiate over an ever greater area until the entire limb or even half of the body is affected, and in severe attacks large areas may be affected so suddenly that the point of origin may not be obvious. Radiation is not in the distribution of the skeletal nerves, and the type of pain is similar to that which Leriche (1939) has attributed to disturbance of the sympathetic neuro-vascular mechanism. In many cases obvious disturbances of the autonomic nervous system have been observed, such as hyperthermia or hypothermia affecting the related limb, disturbance of sweating, and Horner's syndrome (Masson, 1924). Osteoporosis may occur, possibly due to local vasodilatation. Unquestionably, some glomus tumours are painless (Mackey and Lendrum, 1936), but such will rarely occasion surgical intervention. Pain may develop after a number of years. On the other

Autonomic disturbances

Painless tumours

hand, paroxysmal pain may antedate considerably the discovery of the minute lesion in which it originates. During attacks of pain the tumour is frequently observed to become swollen and tense. *Engorgement*

6. AETIOLOGY

In a considerable proportion of recorded cases the development of a glomus tumour has been preceded by a single severe trauma to the site (Bailey, 1935). *Trauma*

7. DIFFERENTIAL DIAGNOSIS

The painful syndrome occasioned by these tumours is so characteristic that it is probably pathognomonic, and it permits even retrospective identification of such lesions as Wood's (1812) "painful subcutaneous tubercle" as glomangioma. Occasionally ordinary subcutaneous cavernous angiomas are sensitive to pressure and subject to attacks of moderately severe pain. (Lendrum and Mackey, 1939.) *Painful angiomas*

8. TREATMENT

The severity of the pain is such that the patient will often request amputation if necessary to be rid of it. Fortunately removal of the tumour under local anaesthesia is simple and effective. Occasionally there is recurrence, due presumably to incomplete removal. *Local excision*

REFERENCES

Bailey, O. T. (1935). *Amer. J. Path.*, **11**, 915.
Lendrum, A. C., and Mackey, W. A. (1939). *Brit. med. J.*, **2**, 676.
Leriche, R. (1939). *The Surgery of Pain*, trans. and ed. by A. Young. London; Baillière.
Mackey, W. A., and Lendrum, A. C. (1936). *Brit. J. Surg.*, **24**, 208.
Masson, P. (1924). *Lyon chir.*, **21**, 257.
Popoff, N. W. (1934). *Arch. Path.*, **18**, 295.
Wood, W. (1812). *Edinb. med. surg. J.*, **8**, 283.
[References to other titles are given under Glomus Tumours in the Index Volume.]

GLOTTIS—OEDEMA OF

By I. G. ROBIN, F.R.C.S.
Surgeon (Ear, Nose and Throat), Royal Northern Hospital; Laryngologist, Royal Chest Hospital; Assistant Surgeon, Ear, Nose and Throat Department, St. Mary's Hospital, London

1. DEFINITION

True position of oedema

Acute and chronic

171.] The glottis is obstructed by oedema that occurs above and below it. The term, oedema of the glottis, is thus a misnomer. The oedema is a clinical phenomenon of a variety of diseases, and not a specific one. The important form is the acute one, but the most chronic type may suddenly become an emergency.

2. ANATOMY AND MORBID ANATOMY

Loose submucosa

The submucosa of the supraglottic and infraglottic structures is deep and loose, especially in the ary-epiglottic folds and epiglottis, and to a lesser degree in the ventricular bands: it can therefore swell enormously. (Fig. 181.) Swelling is more common above than below the glottis.

Size in relation to age

The glottis is relatively smaller in the infant than in the adult, and therefore even more easily occluded.

The oedema is usually serous, but in some acute inflammations it is sero-sanguineous. In tuberculosis there is thickening by infiltration (better termed "pseudo-oedema") but true oedema may be superadded. Delayed radiation reactions cause true lymphoedema from stasis.

The mucosa is markedly injected in inflammatory types with surface flecks of exudate; it is pale or purplish, smooth and shiny in other types.

3. AETIOLOGY

Early diagnosis and treatment are helped by recognition of the many potential causes. These are: (1) inflammatory and (2) non-inflammatory.

(1) Inflammatory

(a) Acute infections

These are more common in children.

(i) *Local infection* by streptococci, staphylococci, pneumococci or *Haemophilus influenzae.*

(ii) *With laryngitis* in measles, scarlet fever, mumps and smallpox; in the early stages of typhoid, in severe influenza, erysipelas, pneumonia, rare cases of hydrophobia, acute tracheo-bronchitis, and the membranous stage of laryngeal diphtheria.

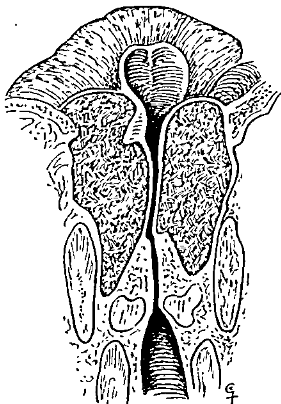


FIG. 181.—Coronal section of larynx behind epiglottis after injection of fluid into ary-epiglottic folds to simulate oedema.

(iii) *Rarely* in quinsy, Vincent's infection, Ludwig's angina, retropharyngeal abscess and agranulocytic angina.

(iv) *Accompanying perichondritis* due to syphilis, tuberculosis, cancer and fractures, especially compound ones.

(b) Secondary to trauma

Oedema follows the inhalation of steam or the drinking of boiling water or caustics; inhalation of poisonous gases of the vesicant type; electric burns, or wounds by bullets, stabs or razors; fractures unassociated with perichondritis (mentioned above), but especially when compound; operations on the larynx and the therapeutic application of caustics.

Impaction of a foreign body in the larynx, any trauma during its removal, a non-metallic body in the trachea or bronchus, and lengthy bronchoscopy are all important causes, especially in children.

X-rays or radium may cause early serous or late lymphoedematous reactions. Subglottic oedema may follow intubation and too high a tracheotomy.

(2) Non-inflammatory

(a) Accompanying systemic diseases

Oedema of the glottis occurs in acute and chronic nephritis, and in angioneurotic oedema or Quincke's disease (exhibiting intense urticarial or "allergic" oedema of bluish-pink colour). Lesser degrees occur in severe cardiac failure with anasarca, in myxoedema, cirrhosis of the liver and acromegaly.

(b) Caused by drugs

Iodides and occasionally aspirin may cause oedema.

(c) Due to pressure on vessels

This pressure may be due to goitre, aneurysm or enlarged bronchial glands.

4. CLINICAL PICTURE

Early signs

The onset is often subtle and insidious. Three early signs are constant: difficulty in swallowing, slow laboured breathing and a hoarse whisper, as with a quinsy.

Later signs

Later there is a rough, croupy cough, pain on swallowing, more marked dyspnoea (of inspiratory character), a noisy stridor, and indrawing at the suprasternal notch. The patient is ashy-grey, restless, anxious and yet drowsy. Cyanosis develops late. In inflammatory types, pyrexia is present and a rigor may occur.

If oedema is subglottic only, the cough is more "croupy" and dysphagia is absent. The dyspnoea is expiratory or both inspiratory and expiratory. The degree of obstruction tends to fluctuate if spasm occurs.

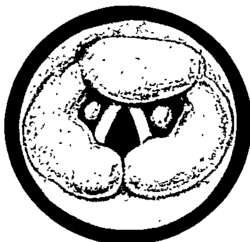


FIG. 182.—Laryngeal mirror appearance of "turban oedema" of epiglottis and aryepiglottic folds.

Laryngeal appearance

The vocal cords are obscured by a "turban-like" epiglottis and aryepiglottic folds (Fig. 182). In the subglottic type, sluggish cords appear to sit on fat cushions.

5. AIDS TO DIAGNOSIS

Laryngeal inspection

These may be impossible or unnecessary. In adults a laryngeal mirror may possibly be used; in children a finger is sometimes advocated to feel the swollen epiglottis. A laryngoscope may be used in less urgent cases.

Laboratory tests

Laryngeal swab, blood and sputum tests and skiagrams of the chest help in the diagnosis of diphtheria, syphilis, agranulocytosis and tuberculosis. Tomography is useful in chronic and subacute cases.

6. DIFFERENTIAL DIAGNOSIS

The most important is from diphtheria, in which the "false membrane" causes noisy *stridor*, marked *"croupy" cough and paroxysms of suffocating dyspnoea* from the onset.

Other diseases are laryngitis stridulosa (infective) and laryngismus stridulus (spastic) in children, functional spasm, nerve palsies, bulbar poliomyelitis, fractures of the larynx, emphysema, perichondritis, retropharyngeal abscess, tuberculous granulations, benign and malignant neoplasms, congenital cysts, aerocoeles, and haematoma following dental extraction in haemophiliacs.

7. PROGNOSIS

This depends upon the cause and the promptness in relief of obstruction. It is worse with acute infections, tuberculosis and cancer; also if cyanosis develops, as death may suddenly occur from heart failure, asphyxia or toxaemia, even after a tracheotomy.

8. INDICATIONS FOR SURGICAL INTERVENTION

Increasing asphyxia calls for prompt action, even if the diagnosis is in doubt. *Increasing asphyxia*

9. PRE-OPERATIVE MEASURES

If time allows, sulphonamides and penicillin are given in inflammatory cases. A steam kettle may be soothing. Ice to the neck and a throat spray of adrenaline and cocaine, 5 per cent, may be applied. With irritant gases a spray of liquid paraffin is useful; with iodides, sodium bicarbonate is given by mouth or injection. In all cases opiates should be avoided.

The occasional delay in obtaining instruments for tracheotomy may be tided over by the passage of a small bronchoscope or intratracheal tube.

10. OPERATIVE TECHNIQUES

(1) Laryngotomy

This is used only in cases of extreme urgency in adults. A child's larynx is too small. A horizontal incision (Fig. 183) is made boldly, through the cricothyroid membrane, the handle of the scalpel twisted to open it, and a tube inserted. A laryngotomy tube, small tracheotomy tube or rubber tube with a safety-pin is used. Haemorrhage is negligible. *Stab incision*

Tube pressure on the cords necessitates a low tracheotomy if relief is needed for longer than a few hours. *Limitations*

(2) Tracheotomy (*see* Air Passages in Vol. I, p. 150)

(*a*) *Position of patient*

A child is wrapped tightly in a sheet. The patient is placed close to the right edge of the table, with a pillow under the shoulders. A nurse holds the head fully extended and exactly in the midline.

(*b*) *Anaesthesia*

In young children a little chloroform is necessary. In all other cases local anaesthetic is injected from the lower border of the thyroid cartilage to the jugular notch, and infiltration is made down to the trachea.

(c) Operation

Incision

A midline incisionfrom the upper border of the cricoid to the jugular notch is deepened to expose the cricoid. The fascia attached to the lower border is incised transversely, and a closed haemostat passed behind the isthmus of the thyroid gland, which is clamped and divided. The first four rings of the trachea are exposed.

Exposure of trachea

Opening trachea

After injecting 2½ per cent cocaine through the trachea a vertical incision is made, from below upwards, through the fourth, third and second tracheal rings (Fig. 183). A tracheal dilator, or hook, is inserted, slices of one or more rings are removed to make the opening oval in shape, and the outer tracheotomy tube is inserted sideways and then turned round to the midline. Complete haemostasis is obtained before the skin is sutured.

Insertion of tube

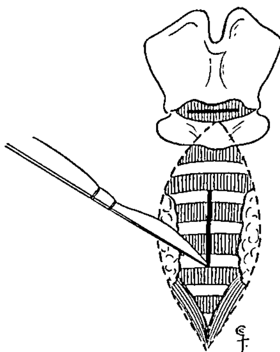


Fig. 183.—Tracheotomy and laryngotomy openings. Edge of scalpel upwards for incision of tracheal rings from below.

Type of tube

Parker tubes are best for children and Durham tubes for adults. Size is important—too short a tube fails to stay in the trachea, and too narrow a one causes emphysema in the neck.

(d) Special modifications

If the surgeon has no assistant, a hook under the cricoid to steady the trachea before opening it is advocated.

"Stabbing the trachea" in children

In children, the "stab" method is permissible in extreme urgency. A 3-inch incision is made downwards from the cricoid, a hook is inserted and the larynx elevated. With knife-edge uppermost, a smart stab is made ½ inch below the cricoid. The hook is handed to an assistant, and a haemostat guided along the knife-blade and opened. A tube is inserted. Only then is the hook removed.

(e) Operative precautions

Necessity for carbon dioxide

A cylinder of carbon dioxide should be handy; if acute obstruction follows on chronic obstruction, sudden decompression leads to a fall in the blood carbon dioxide level and the respiratory centre may fail to be stimulated.

(f) Operative measures which are inadvisable

Intubation is never advisable if oedema is present.

Punctures of the oedematous tissue are unsatisfactory.

11. POST-OPERATIVE CARE

Attention to tube

(1) The inner tube is kept clean, and may be changed every 2–3 hours. The outer tube need not be changed during the first week. After successful removal

of a foreign body, the tube should be kept in for a few hours; in acute inflammatory conditions it is usually dispensed with in a few days; in serious progressive diseases the tube will be permanently employed. After removal the wound granulates over quickly, and sutures are rarely required. Delayed removal causes stenosis in the disused larynx, granulations followed by cicatricial webs and loss of the habit of breathing through the larynx. *Removal of tube*

(2) Cardiac and pulmonary complications must be treated. In inflammatory cases chemotherapy is continued until toxaemia has disappeared. Steam is rarely necessary. *General therapy*

(3) An oesophageal tube may be necessary for feeding purposes during the first few days. *Feeding*

12. CONCLUSIONS

Obstruction of the glottis by oedema above or below it must be relieved by early tracheotomy.

BIBLIOGRAPHY

Bailey, H. (1940). *Emergency Surgery*, 4th ed. Bristol; Wright.

Diseases of the Nose, Throat and Ear, 4th ed. (1936). Ed. by Turner. Bristol; Wright.

McKenzie, D. (1927). *Diseases of the Throat, Nose and Ear*, 2nd ed. London; Heinemann.

Mulvany, J. H. (1942). *Brit. med. J.*, **1**, 638.

Stevenson, R. S. (1935). *Recent Advances in Laryngology and Otology*. London; Churchill.

— (1943). *The Ear, Nose and Throat in the Services*. London; Oxford University Press.

Surgery of Modern Warfare, 2nd ed. (1942). Ed. by Hamilton Bailey. Edinburgh; Livingstone.

Thomson, St. C., and Negus, V. E. (1937). *Diseases of the Nose and Throat*, 4th ed. London; Cassell.

Wright, J. (1914). *A History of Laryngology and Rhinology*, 2nd ed. Philadelphia; Lea and Febiger.

[References to other titles are given under Glottis—Oedema of in the Index Volume.]

GONORRHOEA

By R. C. L. BATCHELOR, D.P.H., F.R.C.S.Ed.
Clinical Officer, Edinburgh Corporation Venereal Disease Scheme;
Surgeon-in-Charge of Venereal Diseases, Edinburgh Royal Infirmary

1. DEFINITION

172.] *Gonorrhoea is the name given to an inflammation* caused by the invasion of certain tissues by a specific micro-organism, the gonococcus of Neisser. The tissue frequently and, in the male, obviously affected is the mucous membrane lining of the urethra, and the pus flowing out from the external orifice of the inflamed urethra, like a discharge of semen, is the outstanding feature which has given the disease its name.

2. AETIOLOGY AND PARTS AFFECTED

Sex and age

In the male sex, in Britain, gonococcal infection is uncommon in very young boys. In men and women, *gonococcal infection is almost invariably* transmitted through sexual intercourse, either natural or perverted. In adolescent and adult males, not only does the gonococcus attack the urethra and the parts adjoining, such as the peri-urethral tissues, the prostate gland and the seminal vesicles, but it may make its way to parts remote from the urethra, such as the epididymes. In the adult female, in addition to attacking the urethra, the gonococcus usually effects a lodgement in the canal of the cervix uteri; also, but much less frequently, in the glands of Bartholin and their ducts; and, in addition, in the rectum. The organism may attack the conjunctiva, and is pecially prone to do so in the newly-born child, thereby producing one of most menacing types of ophthalmia neonatorum. In young girls under ge of puberty the vulva and vagina, and the anus and rectum, in addition he urethra, are susceptible to invasion, and in these immature girls the

infection is usually conveyed accidentally through the medium of infected articles such as bed-clothes soiled with pus, or pus-contaminated towels or sponges. In adults of both sexes, due to a perversion of the sexual act, gonorrhoea of the anus and rectum is not very uncommon in Great Britain. Furthermore, the organism, or its toxins, can be carried by the blood stream away from the genito-urinary regions to settle in and cause inflammation of distant structures, such as joints, or the iris or the conjunctiva.

3. BACTERIOLOGY

The gonococcus belongs to the group of Gram-negative diplococci. Under the $\frac{1}{12}$-inch oil-immersion lens, when suitably stained, it is seen as paired cocci (diplococci), oval in shape, with the opposed surfaces flattened or concave. Each coccus measures about $0{\cdot}8\mu$–1μ in diameter. In purulent exudates the diplococci are usually found in the cytoplasm of the pus cells, and the protoplasm of the polymorph leucocytes is frequently filled with large numbers of ingested gonococci. The infectivity of the gonococcus is limited by its inability to live long when outside the body. If gonorrhoeal discharges are allowed to dry, the organism dies quickly. To keep it alive, it must be kept moist and at body temperature, and this susceptibility to drying and to change of temperature must be kept in mind when an attempt is made to grow the gonococcus in culture. It grows best at body temperature (37° C.) in presence of air, and it requires a medium containing blood or serum or some body fluid. Typical colonies appear at first as translucent discs, circular and discrete, of pin-head size, and, in a mixed growth, may be distinguished by the oxidase reaction which consists in flooding the surface of the medium in the plate with the special reagent, pouring it off again and watching for the development of the typical colour-change to deep purple. Whereas this colour reaction is not absolutely peculiar to the gonococcus, the non-development of the colour-change is helpful in deciding that gonococci are not present in the mixed growth. The identity of the organism in typical-looking colonies should be established by making and examining smears.

Intracellular invasion

Infectivity

Culture

Oxidase reaction

4. DIAGNOSIS

In clinical practice it is usually possible to determine the diagnosis by making smears of the discharges from the parts affected and staining these by a method which will differentiate effectually between the various organisms which may be found in such exudates. A suitable and convenient staining technique is the Jensen modification of the Gram stain in which a 0·6 per cent solution of methyl violet is applied to the fixed smear for 30 seconds; next, Lugol's iodine solution is allowed to act for 30 seconds; then decolorization is effected by washing with alcohol (industrial spirit) for about 30–60 seconds; finally, an aqueous solution of neutral red (containing acetic acid) is used as a counter-stain for 3 minutes. If, in smears so prepared, Gram-negative kidney-bean-shaped diplococci of $0{\cdot}8\mu$ diameter can be demonstrated, and especially if these diplococci are in the intracellular relationship to the polymorphs, then in most of the cases in males it can be accepted that the diagnosis has been satisfactorily established. Nevertheless, whenever it is desirable to eliminate doubt, the procedure already described should be supplemented by ascertaining the action of the organism in question on the sugars glucose,

The Jensen-Gram stain

Biochemical reactions

maltose, saccharose and lactose. Of these carbohydrates, the gonococcus ferments glucose only.

Diagnostic tests should invariably precede treatment

It should be routine practice to make smears for diagnostic purposes before treatment is commenced. In urgent cases, such as, for example, acute salpingitis, it may be desirable to start treatment without waiting for the results of tests, but the smears should be made nevertheless to be sent to a bacteriologist or examined later when opportunity offers. It is not legitimate that a diagnosis of gonorrhoea should be presumed—a urethral discharge and dysuria may result from causes other than gonorrhoea, and these other causes may carry no implication of marital infidelity.

The gonococcal complement fixation test

Testing for concomitant syphilis

If conditions such as profuse menstruation or extreme phimosis should render the taking of reliable smears impracticable, it usually is quite possible to take 10 cubic centimetres of blood for the gonococcal complement fixation test. Whereas half this quantity of blood would suffice for the gonococcal complement fixation test, it is desirable to ascertain the readings of the Wassermann and Kahn tests also. A concealed subpreputial, or intra-urinary meatal or cervical or anal chancre may produce a discharge which may at first be regarded as gonorrhoeal. In this connexion it is vitally important to have a clear realization of the validity of the serological tests. When the first manifestations of gonorrhoea, usually discharge and dysuria, appear, the gonococcal complement-fixation test is negative. If the disease is allowed to persist, and especially if complications (such as prostatitis or salpingitis) occur which lead to blood-borne spread of gonococcal toxins, then antibody formation in the blood will, as it increases, produce gradually increasing intensities of positivity in the gonococcal complement fixation test. Time is therefore required for this test to attain positivity. During the first week of the disease 27 per cent of positive results may be recorded. The proportion of positives increases in the second, third and fourth weeks, and in the fifth and sixth weeks the majority of untreated cases will give positive gonococcal complement fixation tests (Price, 1933). The influence of the time factor in limiting the validity of the serological test renders doubly important the adoption of the routine practice of making diagnostic smears.

5. GONORRHOEA IN MEN

Genito-urinary manifestations

Symptoms and signs

After an incubation period of, on the average, from 2 to 10 days, symptoms and signs appear. The patient feels discomfort in the urethra near the urinary meatus, and soon notices an extrusion of secretion from the urethra, which in most cases rapidly increases to become a frankly purulent, often profuse, discharge. The inflammatory reaction following invasion by gonococci is much more intense than that caused by most of the other organisms which may infect the urethra, and is expressed by such signs as redness and swelling of the lips of the urinary meatus. This intense inflammation is characteristic and, when it occurs, implies a strong likelihood of the infection being gonococcal.

Appearance of the urinary meatus

Nevertheless, cases in which the signs are atypical occur sufficiently often both with gonococcal and non-gonococcal infections to render imperative the need for routine microscopical examination of smears of the discharge. Even if the infecting organism be the gonococcus, the signs of inflammation may

sometimes be slight, and, on occasion, non-gonococcal (for example, streptococcal) infections may be accompanied by severe inflammation. In a typical gonococcal infection, in the absence of treatment, the redness and swelling may extend from the urinary meatus to include the glans penis, prepuce, and even the whole organ. The discomfort in the urethra increases to a burning sensation, and then to hot pain which may be severe on micturition. Gonococci may penetrate to the deeper tissues of the anterior urethra and cause a peri-urethral abscess, or from the bulbous portion may pass along the ducts of a Cowper's gland and cause an abscess to form between the two layers of the urogenital diaphragm. As time goes on, the inflammation tends to spread to the posterior urethra, and in particular when this has occurred, the dysuria becomes worse, the pain being especially pronounced at the end of micturition, and frequency and urgency of micturition add to the patient's distress. The nearest lymphatic glands, those in the inner thirds of the groins, may become swollen and tender, and, in these severe cases there may be a general constitutional disturbance with malaise and fever.

Extension to the posterior urethra

Spread from the posterior urethra to the prostate gland is commonly *associated with an intensification of the pain during and at the end of micturition*, and intensification also of the distressing frequency and urgency. There is continual desire to void, very little urine being passed, and the spasm of the muscles controlling the act is exquisitely painful. An abscess of the prostate tends to burst and drain into the posterior urethra; before doing so it may cause retention of urine.

Extension to the prostate gland

Extension of the infection up the common ejaculatory and excretory ducts to the seminal vesicles is signalled by the addition to the manifestations just described of such suggestive symptoms and signs as painful erections, bleeding after micturition, blood in the last portion of urine passed, and, occasionally, painful emissions of blood-stained semen.

Extension to the seminal vesicles

Further extension along the vas deferens, or by way of the lymphatics, leads to involvement of the epididymis and especially of the globus minor (lower pole) of that organ. This spread causes pain in the spermatic cord running along the line of the inguinal canal down into the testicle. If on the right side, pain sited low in the right iliac fossa may simulate the pain radiating from the inflammation of an appendix, especially one directed downwards into the pelvis. Rigidity of the abdominal muscles is, however, absent, the febrile temperature tends to be higher (102°–104° F.), and the pulse rate lower in relation to the temperature. The constitutional upset in commencing epididymitis may be considerable, but the illness is less profound, and the impression conveyed of a lesser menace tends to focus attention on the search for signs of a urethral infection. When epididymitis is impending, the urethral discharge may lessen in amount, but the urine contains pus and remains hazy, and palpation per rectum may disclose swelling, heat and tenderness of the prostate and seminal vesicles. If the secretion from the urethra be scanty, it is easy to make smears for diagnosis by centrifuging the urine and using the deposit.

Extension to the epididymis

Simulation of appendicitis

6. DIFFERENTIAL DIAGNOSIS

Besides the gonococcus, the other organismal causes of urethritis can usually be distinguished by their morphology and staining reactions as seen in Jensen-Gram-stained smears of secretion from the urethra. Any one of the usual

Urethritis due to other pyogenic organisms

pyogenic organisms, such as staphylococci, streptococci, diphtheroid bacilli (these three groups all Gram-positive), may, on occasion, cause a urethritis and be found in smears of the discharge, either alone or in combination. The presence of Gram-negative bacilli of the coliform group may determine a widespread or localized infection of the urinary tract, and these organisms may be incriminated as the aetiological factor in a urethritis.

Infection with B. coli

Sulphadiazine-resistant coliform infection, with persistently hazy urine, should arouse a suspicion of calculi in the urinary bladder or kidney pelves, and calls for straight x-ray examination of the whole urinary tract, as a precursor of fuller investigation as indicated, including cystoscopy and pyelography. A mixed infection of coliform bacilli and streptococci may occur in a case of stricture of the urethra, especially one in which infection of the urinary bladder has developed.

Infection in stricture of urethra

If only pus cells, with a varying proportion of epithelial cells, are found in repeated examinations of smears of a urethral discharge, and neither gonococci nor any of the other ordinary pyogenic cocci can ever be demonstrated, there remain various possibilities including the following.

Other causes of urethritis

Urethritis may be induced by the irritation of chemicals (such as prophylactic applications or contraceptives used by either sex), or by trauma following a combination of excess both in alcohol and in sexual intercourse. Irritation from the wrong use of irrigation is uncommon in these days of treatment by penicillin.

A persistent slight increase of secretion causing the lips of the urinary meatus to adhere together may be due to excessive stimulation from inordinate sexual excitement or frequently practised masturbation, and in these cases prostatorrhoea or spermatorrhoea may lead to the finding of spermatozoa in the urethral smears.

Trichomonas vaginalis

Urethritis caused by infestation of the urethra, and occasionally also of the prostate, by the protozoal parasite, the *Trichomonas vaginalis,* is not common. The best method of testing for trichomonads is to examine directly with the high power a wet preparation of a drop of the secretion covered by a cover-slip, undiluted if watery, or mixed with a loopful of saline (Liston, 1940). The erratic movements of the trichomonads are unmistakable. The wife of the patient or his sexual partner should be examined and, if necessary, treated with Stovarsol vaginal compound tablets, 2 each night, in courses of 6 nights. Treatment for the male patient may include an alkalinizing mixture containing 30 grains each of potassium citrate and potassium bicarbonate, and also intra-urethral injection of Stovarsol cream (from a collapsible tube with a nozzle).

Abacterial pyuria

Presence of pus and absence of organisms in smears either of urethral secretion or of the deposit from centrifuged urine may be an indication of what is known as "abacterial pyuria". The cause of this condition is not known, but it responds to a short course of 3 intravenous injections each of 0·3 gramme Novarsenobillon (neoarsphenamine) once weekly (Donovan, 1945).

Reiter's disease

A purulent urethral discharge not containing any organisms demonstrable by the ordinary staining methods is one item of the interesting syndrome known as Reiter's disease. The possible components of this syndrome, in addition to a urethritis manifested by a purulent urethral discharge, pyuria and sometimes haematuria, are pyrexia, toxic conjunctivitis, arthritis, and

hyperkeratotic eruptions on the skin of the penis and scrotum, or of the soles of the feet, or of other parts, such as around joints which have been fomented (Harkness, 1945). The cause of this peculiar association of apparently unrelated lesions has not been conclusively demonstrated, but is suspected to be a virus. In treatment, the oral administration of such sulphonamides as sulphathiazole or sulphadiazine or the parenteral administration of penicillin are both equally ineffective. Repeated hyperpyrexia, induced in fever cabinets (such as the inductotherm or Kettering hypertherm) for those patients who can pass the preliminary tests (including x-ray examination of heart and lungs, electrocardiogram, blood urea and blood-pressure), or pyretotherapy applied by intravenous injections of typhoid, paratyphoid A and paratyphoid B vaccine, every third day, in increasing doses of 25 million, 50 million, 100 million, rising to 300 or 500 million—these methods of inducing artificial fever may be followed by gradual alleviation of the symptoms. Formerly, this syndrome was thought to be a result of gonococcal infection, but it was often impossible to demonstrate gonococci in the urethral discharge, and the gonococcal complement fixation test was also frequently negative. It is now believed that there may be a combined infection with gonococci and with the presumptive virus agent underlying the syndrome. Reiter's syndrome occurs much more frequently in men than in women.

Artificial fever in treatment of Reiter's disease

7. TREATMENT OF GONORRHOEA IN MEN

The first choice in treatment is penicillin given by intramuscular or subcutaneous injection. When the patient can take a day off work in order to receive the treatment, an exceedingly satisfactory method consists in the administration of 5 injections, each of a dose of 30,000 units, at intervals of 2 hours, the time occupied being 8 hours, and the total dose of penicillin 150,000 units. With this method, cure may be achieved in about 95 per cent of cases (Harrison, 1945). If certainty of cure be a more important consideration than the need for economy in penicillin, then, by stepping up the individual dose to 50,000 units, and the total amount given in the 5 injections to 250,000 units, it should be possible to attain a 2 per cent or even 3 per cent improvement in the percentage cure rate. The form in which the penicillin is used is the sodium salt dissolved in sterile saline or sterile doubly-distilled water, the usual precautions being taken to see that the solvent is fresh and pyrogen-free.

The administration of penicillin by the multiple injection technique

In many cases, however, it may be inconvenient for a patient to take the whole day off work which is required for the 5-injection method. This disadvantage would be avoided if cure could be obtained with only 1 injection, or, at the most, 2 injections. To do this requires that the usually rapid absorption and excretion of the penicillin (as from saline solutions of the sodium salt) be so delayed that an effective concentration in the blood is maintained for the 8 or 10 hours necessary to ensure the destruction of all the gonococci in the patient's genito-urinary tract. This requirement of delay in absorption may be secured by employing the technique devised by Romansky and Rittman (1944), which is the suspension of the penicillin (calcium salt) in peanut oil (ol. arach.) containing a proportion, say 4 per cent, of beeswax. With this method it is advisable to increase the single, and in this case also

the total, dose to from 375,000 to 400,000 units. Preparations of penicillin-oil-beeswax (P.O.B.) are much less easy to handle than the saline or distilled-water solutions, for if not warmed and kept at well above body heat while in use, the oil-wax vehicle is liable to clog the piston of the syringe and to block the needles used. To avoid these difficulties, the syringe, after sterilization by boiling, must be rendered thoroughly dry and kept hot. The intramuscular needles should be of large bore, not less than 18 standard wire gauge, and 17-bore needles are preferable for some of the preparations. The needles should be sterilized by boiling, then dried and used hot. The cure rate achieved by one single injection of penicillin-oil-beeswax carrying a dose of about 400,000 units is likely to remain above 90 per cent.

A simple and efficient "2-shot" technique

A method which is both time and labour saving, simple, and speedily and easily applied, is a 2-injection technique using the easily prepared saline or aqueous solutions of the sodium salt (Batchelor, Donald and Murrell, 1946b). Each individual dose is 200,000 units dissolved in 4 millilitres of sterile saline. The interval between the two intramuscular or subcutaneous injections is from 6 to 8 hours. In male cases a cure rate of over 95 per cent may be achieved by this method.

Treatment of cases which relapse

Cases which relapse after any of the single, double or multiple injection techniques described above may be cured by a repetition of the method initially used, or by increasing the individual dose and the number of injections given, or by the latter method only.

Treatment of cases showing complications

Cases with adnexal complications such as prostatitis or epididymitis should be admitted to hospital and treated by multiple 2-hourly or 3-hourly injections: such cases usually require about 48 hours of treatment, that is, sixteen 3-hourly injections, each of 50,000 units, to a total of 800,000 units. A periurethral abscess should be aspirated and the cavity filled with 1 millilitre or more of saline solution of sodium penicillin carrying 50,000 units in each millilitre. An abscess of a Cowper's gland points in the perineum to one or other side, and should be opened and drained by an incision parallel to the median raphe. In these abscess cases parenteral treatment should be given also.

Sulphonamide therapy

If a patient should prefer oral treatment to injections, or in the rare event of injections being contra-indicated, sulphathiazole or sulphadiazine may be given in an average dosage of 5 grammes (10 tablets) a day for 5 days. Divided doses are employed, the usual dose being 2 tablets (1 gramme) every 4 hours, given 5 times during the daytime. It is good practice to give two double doses (of 2 grammes each) to begin with. The tablets should be chewed or crushed and swallowed with a ½-pint tumblerful of water. During each 24 hours, between the doses, 7 extra tumblerfuls of water should be consumed, thereby ensuring a fluid intake of not less than 6 pints in the 24-hour period. An alkaline diuretic mixture, carrying a dose of 20-30 grains each of potassium citrate and potassium bicarbonate in ½ ounce of chloroform water, may with advantage be prescribed to be taken concomitantly. If these directions are carried out, intolerance so severe as to demand the cessation of the drug within the 5 days of treatment is exceedingly uncommon, except in patients who have previously shown such intolerance to a sulphonamide as drug fever and skin eruptions. If the sulphathiazole or sulphadiazine is to succeed in quelling the infection, it will do so within the 5 days allowed.

Prolonging the administration of the drug beyond 5 days does not add significantly to its effectiveness, but does greatly increase the chance of intolerance occurring. If the first 5-day course of sulphonamide therapy should fail, twice-daily urethral irrigations with 1:5,000 chloramine-T or 1:10,000 potassium permanganate should be employed for from 5 to 7 days, and then another 5-day course of sulphonamide may be tried, using sulphadiazine if sulphathiazole was used for the first course and vice versa. This last 10–12 days' routine may be repeated if necessary.

8. GONORRHOEA IN WOMEN

(1) Diagnosis

In women, gonorrhoea is diagnosed by examining smears and cultures taken from the urethra (obtaining secretion by stripping the canal), from the orifices of the Bartholin's gland ducts on either side and from the canal of the cervix. *Trichomonas vaginalis* (protozoal) infestation is a frequent accompaniment of gonococcal infection (Liston and Liston, 1939). Especially after a week from the first appearance of symptoms, the gonococcal complement fixation test of the blood may be helpful within the limits of its validity, but negativity of the test does not exclude the possibility of infection; a one-plus reading arouses suspicion, and two-plus or three-plus results demand the repeated investigation of smears and cultures.

(2) Treatment

Except possibly in pregnancy, parenteral penicillin is the first choice in treatment, the methods adopted and the dosage being the same for women as for men. For an uncomplicated case two intramuscular injections (each of 200,000 units of the dissolved sodium salt), separated by an interval of 6 hours, will give a cure rate of over 90 per cent (Batchelor, Donald and Murrell, 1946b). Penicillin-oil-beeswax has the advantage of maintaining more uniformly an effective blood concentration. One intramuscular dose of 375,000 units in oil-wax, or two doses, each 200,000 units in oil-wax, at an interval of 6 hours, will also give high cure rates. In women, however, it is more difficult to make certain of cure, and when it can be conveniently applied a multiple injection technique using five 2-hourly injections each of 50,000 units is preferable. The trichomonas infestation should be treated by courses of 2 Stovarsol vaginal tablets nightly for 6 nights. *Treatment*

Acute salpingitis is differentiated from acute appendicitis by vaginal or rectal examination disclosing swelling and tenderness in the fornices or lateral to the uterus, and is usually associated with an acute cervicitis and urethritis yielding purulent discharges in which gonococci may be demonstrated. *Complicatio*

Acute bartholinitis without or with abscess formation is usually gonococcal but may be, for example, streptococcal.

Infection of the parameatal (Skene's) ducts or of the endometrium or parametrium may occur. In acute infections it is usually possible to clinch the diagnosis by the finding of gonococci in the discharges. In chronic cases, where there is a shut-in focus, the gonococcal complement fixation test may help, but a Skene's duct may harbour gonococci for weeks or months, with little absorption of toxins and without rendering the gonococcal complement fixation test positive.

(3) Treatment of complications

The severe complications, like acute cervicitis, endometritis and salpingitis, may require 3-hourly injections of doses of 50,000 units of penicillin, repeated day and night for several days, to a total of from 800,000 to 2 million units or even more. A localized Skene's duct infection can often be eradicated quickly by an electric cautery needle. In addition to parenteral treatment, an abscess of Bartholin's gland should be aspirated, and the cavity filled with 1 millilitre or more of a solution of penicillin in saline carrying 50,000 units in each millilitre.

(4) Treatment in pregnancy

Penicillin in a dosage curative for gonorrhoea may apparently delay and prevent the recognition of a concomitant syphilis, with its threat to the child (Batchelor and his colleagues, 1946a). Therefore, in gonorrhoea in pregnant women it seems wise first to try the effect of the well-tolerated sulphonamide, sulphadiazine, in dosage of 5 or 6 grammes per day for 5 days.

9. GONOCOCCAL VULVO-VAGINITIS IN YOUNG GIRLS

(1) Diagnosis

The diagnosis of gonococcal infection in female children is almost always made by demonstrating gonococci in smears and cultures from the vulva, vagina, urethra and anus. Occasionally the symptoms are slight, merely irritation manifested by scratching and possibly a little dysuria and frequency. Every effort should be made to discriminate between gonococcal infection and inflammation caused by staphylococci, streptococci or other pyogenic organisms, or by threadworms. The source of the infection should be sought for especially in the parents. The child should be isolated from other small girls, preferably by admission to the special accommodation provided by the local authorities of the larger areas.

(2) Treatment

To effect a cure in gonococcal vulvo-vaginitis, if penicillin be used only parenterally, high dosage and prolonged treatment may be required. According to the age of the child (usually between 2 and 10 years), the individual dose will be from 20,000 to 50,000 units, the smaller doses to be given 2-hourly and the larger 3-hourly, and treatment should be continued for from 3 to 7 days, the total dosage being from 300,000 to 2,800,000 units. Penicillin may also be applied locally by swabbing the vulva and vagina with saline solution carrying 50,000 units in the millilitre, access to the vagina being obtained by passing a wool-dressed probe through a small Ferguson's type of speculum. If a reasonable dosage of penicillin should fail, sulphathiazole or sulphadiazine may succeed, for example, for a child of 4 years, 1 tablet every 4 hours, up to 5 tablets in the 24 hours, for 5 or 6 days (that is, from 12·5 to 15 grammes).

10. GONOCOCCAL LESIONS OTHER THAN GENITO-URINARY

The syndrome characteristic of Reiter's disease, that is, urethritis, fever, arthritis, eye inflammation and hyperkeratotic skin eruptions (including

balanitis circinata), in whole or part, may apparently be superimposed upon gonorrhoea. Certainly severe gonococcal infections of the prostate and seminal vesicles, or of the uterus and Fallopian tubes, giving rise to metastatic spread, may be associated with any or all of the Reiter's syndrome manifestations, and especially with arthritis.

(1) Diagnosis

In acute cases it is usually possible to find the gonococcus in discharges from the affected region in the genito-urinary tract. As arthritis and other lesions seldom arise before the second or third week of the disease, and as antibody formation is stimulated, the gonococcal complement fixation test of the blood is usually positive, and often strongly positive in the acute gonococcal cases.

(2) Treatment

Theoretically, the introduction, into the cavity of an affected joint, of several millilitres of saline solution of penicillin (containing 20,000 to 40,000 units per millilitre) should be highly effective. In actual practice, it is usually sufficient to give penicillin by intramuscular injection, using a multiple injection technique, say 50,000 units 3-hourly, and maintaining this régime for, say, 5–10 days, according to the severity of the case and the response to the treatment.

Alternatively, successive courses of sulphathiazole or sulphadiazine may be used, each course consisting of 25 or 30 grammes in 5 days.

In men, when the urine clears, twice-weekly prostatic massage and vesicular stripping may be desirable.

11. TESTS OF CURE

Testing for cure of gonococcal infections which have been treated by penicillin or by sulphonamides involves:

(1) Absence of all symptoms and of all signs throughout a period of observation of not less than 3 months. Note, however, that the possibility of the masking of syphilis (as discussed below) renders desirable the extension of the observation to 6 months.

(2) Frequently repeated smears (for example, twice weekly for 2 weeks, once weekly for 4 weeks, then monthly), and cultures of secretion from all the areas liable to attack to be free from gonococci throughout the period of observation; and smears to contain no more polymorph leucocytes than may be accounted for by physiological processes (for example, post-menstrual lochial secretion). In men, early morning (urethral) smears made by the patient are particularly useful. In women, post-menstrual smears or cultures may reveal a latent infection.

(3) Reversal to negativity of the gonococcal complement fixation test of the blood, if this test should have attained positivity. In a small proportion of cases, however, persistent positivity may not mean persistent infection.

(4) Provided the patient has shown no clinical signs of syphilis (such as a penile erosion or enlarged lymphatic glands or a skin rash), negativity of the Wassermann and Kahn tests of the blood at the beginning of the period of

observation, and 1, 3 and 6 months after the cessation of anti-gonorrhoeal treatment.

(5) Provocation by the passing along the urethra of straight and curved bougies *may be attempted 4 weeks after the cessation of treatment*, although this seldom succeeds in causing the return of a discharge containing gonococci in cases which have been persistently and adequately investigated by the examination of smears and cultures.

Urethroscopy may be dispensed with in cases which have shown no *complications* and which have responded *well* and *quickly* to penicillin or sulphonamide chemotherapy, that is, in all except around 5 per cent of cases.

The dosage of penicillin (150,000–400,000 units) sufficient to clear up most cases of gonococcal infection is quite insufficient to cure early syphilis (which requires about 5 million units), but may delay the appearance of the chancre or render unreliable (that is, negative for *Spirochaeta pallida*) the dark field examinations of serum from erosions which subsequent positivity of the Wassermann or Kahn tests, or of both, shows to have been probably manifestations of the more slowly incubating disease, syphilis. In penicillin-treated cases of gonorrhoea, therefore, observation should be prolonged for 6 months (Batchelor, Donald and Murrell, 1946b).

REFERENCES

Batchelor, R. C. L., Donald, W. H., Gray, M. S., Jack, R. P., and Murrell, M. (1946a). *Edinb. med. J.*, **53**, 31.
— — and Murrell, M. (1946b). *Brit. med. J.*, **2**, 151.
Donovan, H. (1945). *Brit. med. J.*, **2**, 12.
Harkness, A. H. (1945). *Brit. J. vener. Dis.*, **21**, 93.
Harrison, L. W. (1945). *Practitioner*, **155**, 223.
Liston, W. G. (1940). *Brit. J. vener. Dis.*, **16**, 113.
— and Liston, W. A. (1939). *J. Obstet. Gynaec. Brit. Emp.*, **46**, 474.
Price, I. N. O. (1933). *L.C.C. Publication No.* 2995.
Romansky, M. J., and Rittman, G. E. (1944). *Bull. U.S. Army Med. Dept.*, No. 81, 43.
[References to other titles are given under Gonorrhoea in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 1.]

GOUT

By GEORGE GRAHAM, M.D., F.R.C.P.
Consulting Physician, St. Bartholomew's Hospital, London

1. INTRODUCTION

173.] This disease is associated with the deposition of sodium biurate in the joints, bursae, tendon sheaths, subcutaneous tissues and bones. The uric acid in the blood is low just after an acute attack and rises slowly to above the normal 3 milligrams per 100 millilitres between the attacks, reaching a maximum of 5–6 milligrams per 100 millilitres just before an attack; in chronic cases it may be over 5–6 milligrams per 100 millilitres all the time. The increase in the uric acid is not due to an excess of uric acid being formed, but to a failure of the kidney to excrete it. The cause of this is not known, but may be due either to the uric acid being present in the blood in an unusual form or to a rise in the threshold of excretion of the kidney. Gout occurs more commonly in men than in women. It may occur in boys under 20 years of age, but more usually affects men and women who are over the age of 40 years.

Deposition of sodium biurate

2. AETIOLOGY

There is good evidence that the disease runs in families. Attacks are more likely to occur in those who drink fairly large quantities of beer, red wines and champagne. White wines, cider and spirits are rarely responsible for attacks. The eating of foods which are rich in purine, like sweetbreads, liver and kidneys, may bring on an attack in a susceptible patient. It may occur in people with a strong family history, even though they avoid all the usual contributory causes. An injury either to a joint or to subcutaneous tissues may precipitate an attack. Lastly, gout may develop in a patient who is suffering from any acute disease, or who has had either a major or a minor operation, which does not necessarily involve a joint. Workers in lead used to be especially liable to gout, but lead poisoning occurs so rarely nowadays that this may be discounted.

Avoidance of purine-ri[ch] foods

3. CLINICAL ACCOUNT

The acute attack typically starts in the night hours, causing great pain and a peculiar "boiling" sensation. The joint, or bursa, swells rapidly and the skin becomes red and shiny, and is very suggestive of an acute septic condition. If the big toe is affected, the diagnosis of gout is usually made, but if other situations, such as the terminal thumb joint or olecranon bursa, are affected the diagnosis may be difficult. The swelling may be considerable, the skin very red and shiny, and the pain exquisite, suggesting that pus is present under tension. The patient's temperature may be raised to 100° F. and the pulse rate

Leucocytosis

to a corresponding extent. A blood count may reveal a leucocytosis of 9,000–10,000 or more. The blood uric acid will probably be below 3 milligrams per 100 millilitres of blood after the second day. The absence of fluctuation should arouse suspicion. An x-ray examination will not disclose any abnormal changes unless a joint has been affected many times, in which case the patient would know what is the matter with him.



FIG. 184.—Shows the early changes due to gout in the metacarpal of the thumb and in the carpus; the late stages are shown in the metacarpals of the third and fourth fingers.

A history of previous attacks is one of the first points in differential diagnosis. If the big toe has ever been involved, the diagnosis of gout is made more probable. There is never any evidence of lymphangitis spreading up the limb or tenderness of the axillary or inguinal glands. If these positive and negative points are carefully considered the swelling should not be aspirated at once, but intensive treatment with colchicum should be started and the situation reviewed after 24 hours. If the condition is gouty, a great decrease in the pain will have occurred, the swelling will be smaller and less tense and the skin will be wrinkled. If, *on the other hand*, a septic condition is present, the condition will have deteriorated and the appropriate surgical measures should be taken.

Intensive treatment with colchicum

The following prescriptions should be used as soon as possible:

Wine of Colchicum	– –	30 minims
Sodium Bicarbonate	– –	15 gr.
Sodium Salicylate –	– –	15 gr.
Chloroform Water	– ad.	$\frac{1}{2}$ oz.

1 tablespoonful every 4 hours for 3 days or longer.

Note: Tincture of colchicum 15 minums may be prescribed as an *alternative* to wine of colchicum here.

or

Colchicine	– – –	$\frac{1}{84}$ gr.
White Sugar	– – ad.	2 gr.

1 pill every 4 hours for 3 days.

A patient who has once had gout should always have these pills at hand in case an attack starts in the night.

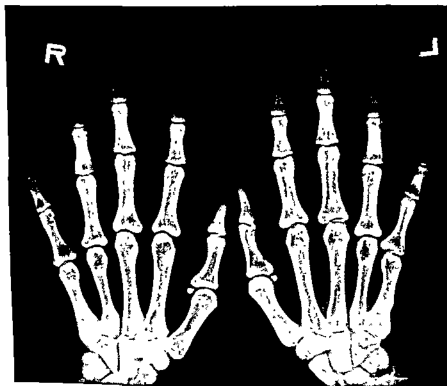


FIG. 185.—Shows the "lace-like" appearance and translucent areas which occur in Boeck's sarcoid.

The effects of trauma may be very baffling. A patient who sprains or fractures an ankle may, some 2 or 3 days later, develop an acute attack of gout in the injured limb. The sudden increase in swelling associated with great pain may be disturbing, especially if the supposed sprain has not been radiographed. Here again a course of colchicum may settle the diagnosis. *Effects of trauma*

The early radiographic changes are small areas of rarefaction which occur usually at the edge of the head of the phalanges or metacarpal or tarsal bones. *Early radiographic changes*

These appear as small holes in the bones. At a later stage the holes get bigger and may involve the shaft of the bone, and later, in occasional cases, the bone may break (Fig. 184). The diagnosis of gout should not be made unless there is plenty of calcium in the bones. In rheumatoid arthritis, disuse atrophy causes rarefaction, and this may reveal small holes which resemble the punched-out areas of gout. In Boeck's sarcoid the radiographic changes are most pronounced in the phalanges of the hands and feet, and in the metatarsals and metacarpals. The periosteum and joints are spared while the medulla is the site of an irregular rarefaction which gives a "lace-like" appearance (Fig. 185) and is combined with occasional clear trans-radiant areas. In the later stages there may be considerable bony destruction and a radiographic picture of sclerosis alternating with rarefaction.

Sequelae

The sequelae of many attacks of gout may call for surgical treatment. The joints and bursae usually affected are those of the hands and feet. The skin over the deposits of sodium biurate may ulcerate and allow a milky fluid to escape. It may be possible to remove a small mass of sodium biurate which is acting as a foreign body and so enable the sinus to heal. Penicillin may be of value in the healing process if the sinus is infected with penicillin-sensitive bacteria.

A phalanx may be so infiltrated with sodium biurate that it breaks. It is usually necessary in this case to remove the whole toe or finger at the appropriate joint level.

A mass of sodium biurate may collect in certain situations and call for surgical treatment; one beneath the Achilles tendon may make walking difficult and its removal may be indicated. Similarly a large mass in the olecranon bursa may cause great inconvenience and should be removed. Very

TABLE

THE PURINE CONTENT OF VARIOUS FOODS (*R. A. McCance*)

MATERIAL (all cooked)	PURINE NITROGEN MILLIGRAMS PER 100 GRAMMES (3½ OZ.) OF EDIBLE FOOD
Brains	33
Mutton (general average)	63
Fish " "	65
Pork " "	69
Beef " "	81
Birds " "	94
Heart	116
Cod's roe (hard)	120
Liver and Kidney	140
Herring (no roes)	150
Smelts	168
Sprats	180
Sardines	234
Whitebait	323
Throatbreads, sweetbreads, etc.	426
Herring roe (soft)	480

large masses upon the phalanges of the fingers or toes may have to be removed. Any of these operations may precipitate an acute attack of gout suggesting that sepsis has occurred, and colchicum should be used at once.

These large masses of sodium biurate are due either to long-standing gout which has not been diagnosed or to inadequate medical treatment. It would be wiser, if possible, to prepare the patient by careful treatment for some 3 weeks before operation. The diet should contain the minimal amount of purine bodies. Practically all protein foods contain some purines but their content varies. Foods which contain more than 100 milligrams of purine nitrogen per 100 grammes should be avoided if possible (*see* Table). Small amounts, say 1 ounce of those containing between 100 and 150 milligrams, would be no more harmful than say 2 ounces of pork, if taken in exchange and not as an addition to the diet. Those containing more than 150 milligrams should not be taken. Alcohol *per se* is not harmful, for example whisky, brandy or gin, well diluted and in small amounts, but all beers, red wines and champagne are liable to cause acute attacks of gout.

Pre-operati preparation

A regular course of aspirin either in the form of calcium aspirin, 10–15 grains, or aspirin, 10-15 grains, with glycine, 14–21 grains, should be given 3 times a day for 3 consecutive days each week. This will aid the excretion of uric acid and reduce the chance of an acute attack very considerably. The dosage may later be given on only one or two days each week depending partly upon the freedom from attacks and partly upon the amount of uric acid in the blood. The dose should not be reduced so long as the uric acid is over 4 milligrams per 100 millilitres. Cinchophen is more efficacious than aspirin but may cause loss of appetite, nausea, vomiting and lastly a hepatitis which may be fatal. For these reasons it should be used very rarely, if at all.

[References to other titles are given under Gout in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 37.]

GUNSHOT WOUNDS AND ALLIED INJURIES (GENERAL MANAGEMENT)

By C. G. ROB, *M.C.*, M.Chir., F.R.C.S.
Surgeon-in-Charge, Out-patients Department, St. Thomas's Hospital, London

1. DEFINITION

174.] For the purposes of this article the term "gunshot wound" is defined as any injury produced by a missile of war. The atomic bomb has been omitted purposely as the author has no experience of the injuries which it produces. Because wounds of the principal organs are discussed elsewhere, this section deals primarily with flesh wounds.

2. AETIOLOGY

Wounding agents

During World War II the principal wounding agents were:

(1) Fragmentation missiles (shell high explosive, mortar bomb, aerial bomb, grenade) 75 per cent.

(2) Solid missiles (bullets, anti-tank shells) 10 per cent.

(3) Concealed charges (landmines, booby traps) 10 per cent.

(4) Indirect injuries (blast, crush) 2 per cent.

(5) Chemical agents (phosphorus) 1 per cent.

(6) Remainder 2 per cent.

3. EARLY MANAGEMENT AND TRANSPORTATION TO THE SURGEON

Early treatment and first aid

The medical management of a gunshot wound begins immediately after injury, and the role of the first doctor to see the patient is very important. After diagnosis he may have to control haemorrhage by pressure or occasionally by tourniquet. He also dusts the wound with sulphanilamide or penicillin-sulphathiazole powder and applies a sterile dressing, splints fractures, applies a dressing seal to thoracic wounds, gives morphine (intravenously if possible), injects tetanus anti-toxic serum or toxoid, commences resuscitation, and arranges a rapid and smooth evacuation. In this connexion the initiation of

"In-ambulanc transfusion"

an "in-ambulance transfusion" of blood-plasma or occasionally whole blood is of great value in selected cases. The importance of continuing the transfusion during evacuation, as opposed to resuscitation and then evacuation without a transfusion running, cannot be over-estimated in severely shocked patients.

Function of evacuating units

In war during the journey to the surgeon the patient will pass through several medical units. Their policy should be one of efficient sorting, minimal intervention and maximal speed. Apart from the control of haemorrhage the dressing should not be disturbed. Splints may require adjustment, the transfusion may need attention, pain may necessitate further morphine, or the patient may be thirsty and hungry. At all stages of the evacuation journey an efficient clinical record must be kept, for this is of great help to the staff at subsequent stages. Chemotherapy, which the first doctor will have started, must be maintained; this will take the form of a sulphonamide, or penicillin, or both, and their regular administration by all medical units during the evacuation both before and after operation is important.

Phosphorus burns

In addition phosphorus burns must be diagnosed and treated as soon as possible. Diagnosis is by the history of wounding by a phosphorus bomb or grenade, the dead-white appearance, extreme pain, and continued burning or phosphorescence in the dark. The urgency for immediate treatment is very great. The part must be immersed in water or, if this is impossible, a soaking-wet dressing is applied; the urgency is such that if water is not available urine should be used. Later the part should be immersed in 5 per cent sodium bicarbonate solution which usually relieves the pain; then it is swabbed with a 1 per cent copper sulphate solution which coats the phosphorus with a dark deposit so that the particles can be removed with forceps. If copper sulphate is not available the particles can be seen and removed in the dark. Finally another wet dressing of sodium bicarbonate is applied and the patient evacuated to the surgeon.

4. CLINICAL PICTURE

The clinical picture may be divided into the patient's general condition and the local condition round the wounds.

The general condition

The general condition varies considerably, but certain findings are common to all battle casualties. They are dirty, tired, often cold and wet, thirsty, and all want an operation. It is a curious fact that a wounded soldier both expects and welcomes an operation; he feels that something is being done for him. The majority have no other general abnormalities, but the minority with severe wounds or gross blood loss are suffering from a varying degree of circulatory failure. The worst cases have a blood-pressure which cannot be recorded, a pulse which cannot be palpated at the wrist, and a very sluggish peripheral circulation.

Fragmentat missile wounds

The local condition depends upon the wounding agent. Thus fragmentation missiles give rise to multiple wounds, and, whilst producing the most extensive wounds of all when the fragments are large, may cause only a minute injury if small. These jagged missiles destroy much tissue, and even if the skin wound is small the deeper structures will be lacerated extensively.

Mine woun

Concealed charges such as mines are buried usually in earth. Therefore the

GUNSHOT WOUNDS AND ALLIED INJURIES (GENERAL MANAGEMENT)

By C. G. ROB, *M.C.*, M.Chir., F.R.C.S.
Surgeon-in-Charge, Out-patients Department, St. Thomas's Hospital, London

1. DEFINITION

174.] For the purposes of this article the term "gunshot wound" is defined as any injury produced by a missile of war. The atomic bomb has been omitted purposely as the author has no experience of the injuries which it produces. Because wounds of the principal organs are discussed elsewhere, this section deals primarily with flesh wounds.

2. AETIOLOGY

Wounding agents

During World War II the principal wounding agents were:

(1) Fragmentation missiles (shell high explosive, mortar bomb, aerial bomb, grenade) 75 per cent.

(2) Solid missiles (bullets, anti-tank shells) 10 per cent.

(3) Concealed charges (landmines, booby traps) 10 per cent.

(4) Indirect injuries (blast, crush) 2 per cent.

(5) Chemical agents (phosphorus) 1 per cent.

(6) Remainder 2 per cent.

3. EARLY MANAGEMENT AND TRANSPORTATION TO *THE SURGEON*

Early treatment and first aid

The medical management of a gunshot wound begins immediately after injury, and the role of the first doctor to see the patient is very important. After diagnosis he may have to control haemorrhage by pressure or occasionally by tourniquet. He also dusts the wound with sulphanilamide or penicillin-sulphathiazole powder and applies a sterile dressing, splints fractures, applies a dressing seal to thoracic wounds, gives morphine (intravenously if possible), injects tetanus anti-toxic serum or toxoid, commences resuscitation, and arranges a rapid and smooth evacuation. In this connexion the initiation of

an "in-ambulance transfusion" of blood-plasma or occasionally whole blood is of great value in selected cases. The importance *of continuing* the transfusion during evacuation, as opposed to resuscitation and then evacuation without a transfusion running, cannot be over-estimated in severely shocked patients. *"In-ambulance transfusion"*

In war during the journey to the surgeon the patient will pass through several medical units. Their policy should be one of efficient sorting, minimal intervention and maximal speed. Apart from the control of haemorrhage the dressing should not be disturbed. Splints may require adjustment, the transfusion may need attention, pain may necessitate further morphine, or the patient may be thirsty and hungry. At all stages of the evacuation journey an efficient clinical record must be kept, for this is of great help to the staff at subsequent stages. Chemotherapy, which the first doctor will have started, must be maintained; this will take the form of a sulphonamide, or penicillin, or both, and their regular administration by all medical units during the evacuation both before and after operation is important. *Function of evacuating units*

In addition phosphorus burns must be diagnosed and treated as soon as possible. Diagnosis is by the history of wounding by a phosphorus bomb or grenade, the dead-white appearance, extreme pain, and continued burning or phosphorescence in the dark. The urgency for immediate treatment is very great. The part must be immersed in water or, if this is impossible, a soaking-wet dressing is applied; the urgency is such that if water is not available urine should be used. Later the part should be immersed in 5 per cent sodium bicarbonate solution which usually relieves the pain; then it is swabbed with a 1 per cent copper sulphate solution which coats the phosphorus with a dark deposit so that the particles can be removed with forceps. If copper sulphate is not available the particles can be seen and removed in the dark. Finally another wet dressing of sodium bicarbonate is applied and the patient evacuated to the surgeon. *Phosphorus burns*

4. CLINICAL PICTURE

The clinical picture may be divided into the patient's general condition and the local condition round the wounds.

The general condition varies considerably, but certain findings are common to all battle casualties. They are dirty, tired, often cold and wet, thirsty, and all want an operation. It is a curious fact that a wounded soldier both expects and welcomes an operation; he feels that something is being done for him. The majority have no other general abnormalities, but the minority with severe wounds or gross blood loss are suffering from a varying degree of circulatory failure. The worst cases have a blood-pressure which cannot be recorded, a pulse which cannot be palpated at the wrist, and a very sluggish peripheral circulation. *The general condition*

The local condition depends upon the wounding agent. Thus fragmentation missiles give rise to multiple wounds, and, whilst producing the most extensive wounds of all when the fragments are large, may cause only a minute injury if small. These jagged missiles destroy much tissue, and even if the skin wound is small the deeper structures will be lacerated extensively. *Fragmentation missile wounds*

Concealed charges such as mines are buried usually in earth. Therefore the *Mine wounds*

resulting wounds are multiple, grossly contaminated with earth and very extensive. Certain mines produce a characteristic clinical picture. The Shüe mine blows off the foot just above the ankle joint, commonly into the opposite calf, in the muscle of which the boot leather and toes may be found embedded. The German anti-personnel mine discharges a number of ball bearings, and the larger anti-tank mine throws up stones, earth and portions of the tank or truck which fired it off.

Solid-missile wounds

Solid-missile wounds are often single. Bullet wounds have a round wound of entry unless a ricochet has occurred, a larger exit wound, and the wound track is surrounded by lacerated tissue. An anti-tank shell wound is rare, but when it occurs with survival of the patient a traumatic amputation is the common finding; this must resemble the cannon-ball injury of the past.

Indirect injuries such as blast may occur with any large explosion, particularly if under water. The patient is often deaf, sometimes cyanosed, and the abdomen may be rigid and require careful observation. If he is shocked due to associated injuries a very poor response is obtained with resuscitation. Falling masonry is the usual cause of crush injuries, when the limb is swollen, tense, cyanosed and pulseless, and oliguria with myohaemoglobinuria may follow.

Indirect injuries

Injuries by chemical agents in World War II have consisted principally of phosphorus burns which have been described already.

Amongst injuries due to other causes stab wounds by a knife or bayonet are seen occasionally.

Multiplicity of war wounds

The previous remarks deal principally with flesh wounds, and although wounds of the other structures are dealt with elsewhere, the following general points are of importance. The multiplicity of war wounds is astonishing; for example, in over 50 per cent of patients with abdominal wounds other injuries are present in addition, and in 20 per cent these are of a major character themselves, for example, compound fractures, traumatic amputations, thoracic or cerebral wounds.

Sorting

In war the sorting or triage of all patients with gunshot wounds is important; it consists of diagnosis and the patients' classification into a priority group for operation. First priority cases for the earliest possible surgical treatment are: all patients with a tourniquet *in situ*, gross muscle wounds (a rough estimate is two fistfuls of muscle destroyed), traumatic amputations, sucking wounds of the thorax, extensive compound fractures, abdominal wounds (although many of these can be delayed for further evacuation if the general condition is good and a better equipped surgical centre can be reached quickly), maxillo-facial cases with an obstructed airway, and cases of tension pneumothorax. Notable exceptions are: neurosurgical, other maxillo-facial (including burns) and ophthalmic cases. These latter should be sent direct to the appropriate special centre with an in-ambulance transfusion if necessary. Usually this will mean a longer journey, but it is well worth while. If such a centre is not available then they must be evacuated as priority patients with the rest.

5. SPECIAL AIDS TO DIAGNOSIS

Radiological examination

Ideally every gunshot wound should have a radiological examination. Not only will this demonstrate metallic foreign bodies, fractures, indriven bone

fragments and intrathoracic damage, but it aids an estimation of the wound track, particularly if the foreign body is retained. Such an aid is very valuable, as a clinical estimate of the wound track is of primary importance in diagnosing the damage done by a missile of war.

Blood examination

During the later stages of treatment a careful watch must be kept on the haemoglobin, red and white cell and protein content of the blood. In patients with abdominal wounds, amputations or chronic suppurating wounds it is remarkable to what low levels the haemoglobin or occasionally the plasma protein may fall; these should be estimated regularly in all such patients.

6. INDICATIONS FOR SURGICAL INTERVENTION

Every gunshot wound (certain arterial haematomas excepted) which penetrates the skin should be excised, because such excision not only diminishes the incidence of infection and decreases the mortality, but if followed by efficient delayed primary or secondary suture it decreases the morbidity.

Time interval and wound excision

Unfortunately, even under the good conditions prevailing during the victorious latter half of World War II this was impossible. A number of patients, particularly enemy prisoners of war, do not reach the surgeon in time for wound excision; these cases should have the wound enlarged and trimmed, but not excised. The operation changes from excision to enlargement in a time interval after wounding which varies with the terrain and the individual case. A rough rule, however, is that excision should never be practised after 18 hours and very rarely after 12 hours from wounding.

Other factors may make excision impracticable. Thus in severely shocked patients with multiple wounds the general condition may allow excision of only the major wounds, the minor having to be left with a dressing. Occasionally a surgeon may become isolated with a large number of casualties on his hands; in these circumstances he will have to select patients for conservative treatment. Through-and-through bullet wounds in which muscle is not involved, small wounds of the thorax, and apparently hopeless cases are amongst those which can be left to the last.

7. PRE-OPERATIVE MANAGEMENT

On admission to a surgical centre the patient is made comfortable, and if practicable he is undressed. Guided by the state of the peripheral circulation, the blood-pressure, the pulse pressure, and the pulse rate the decision is made whether to resuscitate and, if so, how.

Resuscitation

Simple warmth and rest are all that the majority need, because they are suffering from small flesh wounds, the commonest war wound. Those with major wounds and nearly all first-priority patients require, however, active resuscitation in the form of blood, blood-plasma, glucose saline or oxygen, if cyanosed. The exact amounts of these fluids required cannot follow any hard-and-fast rule, but blood should be given in an amount equal to that lost, blood-plasma in sufficient quantity to restore the blood-pressure to the normal level, and glucose saline should be given to those who are dehydrated, dehydration being common amongst battle casualties in tropical and subtropical climates.

Ideally, no patient is operated upon before his blood-pressure approximates

to the normal, but certain patients with continuing haemorrhage or gross muscle wounds need urgent surgery as soon as some response has been achieved. This raising of the blood-pressure to a normal level usually requires prolonged resuscitation, often for several hours. Such a delay is well worth while, for shock is controlled, and surgical procedures, which would be impossible within an hour of admission, can be successfully carried out.

Moribund patients

The satisfactory transfusion service of World War II made it possible to operate upon nearly every battle casualty. The actual number dying in the period between admission and operation was small. Statistics for all war wounds are not available; however, a good guide to the number has been provided by the New Zealand Forces in Italy, where less than 4 per cent of all abdominal wounds, during this period, resulted in death (Stout, 1946).

During resuscitation, or whilst the patient is awaiting operation, all splints and dressings must be checked. Tourniquets must be removed if possible, and a very careful watch kept to see if the raising of the blood-pressure causes haemorrhage to recur.

Morphine

Morphine has been given already to most patients during evacuation, and it is rarely needed after admission. This is particularly so for shocked patients in whom the absorption from subcutaneous injection sites is not completed until resuscitation has improved the peripheral circulation. Premedication is given, and after a suitable interval the patient is sent to the operating theatre with the transfusion running if necessary.

8. THE FIRST OPERATION

Location

In the field the operating theatre may be located in a tent, a building, or occasionally a captured or liberated hospital; but whatever the location and whatever the difficulties, the constant aim of the whole theatre team should be the production of an aseptic technique closely approximating to the best civilian standards. War surgery is largely concerned with overcoming adverse circumstances and in striving to make war conditions as much like peace conditions as possible.

General anaesthesia

The operation commences with the induction of anaesthesia. The most convenient anaesthetic is intravenous Pentothal Sodium, and for the vast majority of casualties it is highly satisfactory. Its use is contra-indicated, however, for patients who have been severely shocked, or those with wounds which may interfere with the airway. These cases and those upon whom a long operation is necessary should be given an inhalation anaesthetic.

Local anaesthesia

Local anaesthesia has an occasional place in forward war surgery, but spinal anaesthesia has little or no place. The only definite indication for local anaesthesia is in patients who require a tracheotomy or are likely to require one during the operation; for these the tracheotomy is performed under local anaesthesia, and general anaesthesia is then induced if further surgery is required. It is also useful for the excision of such injuries as minor thoracic wounds and wounds of the scalp.

After the induction of anaesthesia the wounded areas are washed with soap and water, shaved, and painted with the antiseptic of the surgeon's choice, a large area being so treated. In patients with multiple wounds the decision has to be made as to which wounds are to be treated first. Amputations, wounds with much muscle damage or continuing haemorrhage are the top priority.

Multiple wounds

Wounds of the back, which will necessitate rolling and turning the patient for their excision, are next; for example, a patient with a buttock wound in association with an abdominal wound should have the buttock wound excised first, because he will stand the necessary movement much better before than after his laparotomy.

Flesh wounds, if recent, are fully excised (Fig. 186). The wound is enlarged in such a way that delayed primary suture can follow; this means the conservation of skin at all costs and an incision which follows the skin folds if possible (Fig. 187). Damaged and contaminated subcutaneous fat is excised, and the deep fascia opened to the same extent as the skin, damaged fascia excised and if necessary a second incision made in the fascia at right angles to the first (Fig. 188). All damaged, devitalized or contaminated muscle is removed and all *Wound excision*

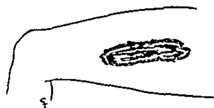


Fig. 186.—A flesh wound; the three diagrams which follow illustrate excision of this wound.

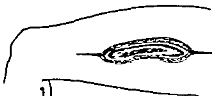


Fig. 187.—Wound after excision of the skin edge and enlargement of the skin wound. It is essential for the surgeon to be conservative when trimming the skin edge.

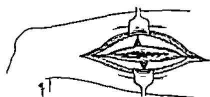


Fig. 188.—Wound after excision of the fascial edge, and incision of the fascia both vertically and horizontally.

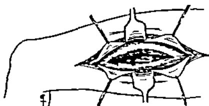


Fig. 189.—Wound excision completed, all damaged muscle excised, and the foreign body removed.

pockets are laid open. The foreign body, if it comes to hand, is removed (Fig. 189), but an extensive search is unnecessary; the importance, however, of removing non-metallic foreign bodies, such as clothing or earth, cannot be overestimated. After haemostasis has been achieved, the wound is dusted with penicillin-sulphathiazole powder and covered lightly with Vaseline gauze. No sutures of any kind are inserted. The larger wounds are placed in a split and padded plaster, and the patient is evacuated to the base as soon as he is fit, treatment being continued with either a sulphonamide or penicillin. *The foreign body*

Wounds involving bones, the abdomen, the chest, the nervous system or other important organs are excised in the same way as flesh wounds. The treatment of these injuries is described elsewhere in this work under the appropriate sections.

There is one flesh wound, however, which requires special mention, the small wound of the calf of the leg. Here the surgeon very commonly is confronted with brisk haemorrhage as soon as he has incised the deep fascia. This is coming usually from the posterior tibial vessels, and the best course is *Wounds of the calf of the leg*

to make a large incision, evacuate the haematoma, and with the aid of a good light find and ligate the bleeding point. This wound can be one of the most troublesome encountered in war surgery.

Wound trimming

Wounds which are seen too late for excision should be enlarged and trimmed. This operation follows the same lines as wound excision, but only tissue the excision of which is necessary for adequate drainage is removed.

Amputations

An amputation is indicated if the limb will not survive, and in some patients with gas gangrene. In war the forward surgeon should not perform a definitive amputation, but aim at the longest possible stump with skin cover. Flaps are cut and the limb is removed in the usual manner, the stump is then dusted with penicillin-sulphathiazole powder, the flaps are draped over the end, a Vaseline gauze dressing is applied and the stump placed in plaster. It is important not to turn the flaps back because they tend to become gangrenous if this is done.

Primary wound suture

The primary suture of flesh wounds has no place in war surgery, unless it is certain that the patient will not be evacuated before his sutures are removed. This means that the flesh wounds in association with an abdominal wound can be sutured if the excision has been complete. Patients with facial wounds from which the sutures are removed in 2–3 days can be held without evacuation for this period. Lawrie (1945) reports 59 minor facial wounds so treated and that 53 of the patients had returned to duty in an average period of 4·3 days—a great saving of man-power when compared with evacuation to the base for delayed suture.

9. THE SECOND OPERATION

In war it is the responsibility of the administrative side of the medical service to ensure rapid evacuation of the patients. The ideal time for the second operation, the operation of delayed primary wound suture, is between the third and sixth days after wounding, and patients must arrive at the base hospital in time for this.

Delayed primary suture

During the interval between the two operations the wound should not be inspected. If inspection is needed then it should be carried out in an operating theatre with full aseptic precautions. The importance of this is demonstrated by the following statistics from the Italian campaign of 1944; of 869 consecutive wounds 163 had been dressed during evacuation; 48 per cent of these 163 wounds were infected with pathogenic bacteria as against 33 per cent of the 706 undisturbed wounds (Edwards, 1945).

Importance of aseptic dressings

At the base hospital the wound is inspected in the operating theatre under anaesthesia if necessary. The decision is then made for or against delayed primary suture. Contra-indications are: acute inflammation (the presence of bacteria or pus is not a contra-indication), the presence of gas in the tissues, incomplete wound excision, and excessive skin loss. The majority of wounds are suitable, however, for suture.

Contra-indications

The operation consists in undermining the skin edges by blunt dissection, trimming off any redundant tags of skin or fascia, dusting with penicillin-sulphathiazole powder, and accurate closure of the skin with interrupted sutures, a fair degree of tension being permissible. If there are deep pockets in the wound, fine rubber penicillin tubes should be introduced into these

Penicillin tubes

through separate stab incisions; they are then closed with a spigot and 2 cubic centimetres of a penicillin solution containing 250 units per cubic centimetre injected down the tube twice daily. In deep wounds a dead space often remains after closure; it is usually better to treat this with penicillin tubes rather than by the introduction of deep sutures. Amputations are particularly suited to delayed primary suture, but here drainage should be employed for 2 or 3 days.

Delayed primary suture of compound fracture

The presence of compound fractures, or of damage to nerves or other important structures, is in no way a contra-indication to delayed primary suture. In compound fractures of the lower third of the tibia, however, closure may be mechanically impossible, and in compound fractures of the femur it is wise to leave the posterior wound open, or if no such wound is present to make an incision at the back of the thigh for drainage, because exudate or pus may collect in this region.

After closure, all fractures and large flesh wounds are placed in a split and padded plaster, parenteral penicillin is given if necessary, and the patient must remain without further evacuation until the sutures are removed. All patients in whom a low haemoglobin or plasma-protein is suspected must have these estimated. If the figure is low it should be corrected by a transfusion of blood or blood-plasma.

Those patients who arrive too late for delayed suture (it can be performed as late as the tenth day), and those on whom delayed suture has failed or was impossible, must have a skin cover provided at all costs. The best method of achieving this is by secondary suture, with skin grafting as a last resort. Secondary suture is superior because it provides a full-thickness skin cover.

Secondary suture

The operation of secondary suture can be performed at any time after the tenth to the fourteenth day. It consists of excision of the granulation tissue, removal of a thin strip of the skin edge, and undercutting the skin for a sufficient distance to make suture possible. Then, after the application of penicillin-sulphathiazole powder, the skin is closed with interrupted sutures.

Skin grafting

Skin grafting should be reserved for those patients on whom secondary suture has failed or was impossible; split-skin grafting with patches is the usual method employed. After every effort, however, a small percentage of wounds remain unhealed, the commoner causes being bone infection, a chronic empyema or a faecal fistula. Late treatment will be required for these.

10. REHABILITATION

On discharge from hospital the soldier proceeds to a convalescent depot. Here he undergoes a course of medically supervised and graduated physical training, the object being to accelerate the change from a hospital patient to a fighting soldier. This is essential, for a soldier must be fit to fight and upon discharge from hospital he certainly is not fit, even if he has been up and about for a very long time.

11. THE RESULTS OF SURGICAL TREATMENT

In August and September 1918, of 5,539 casualties arriving at two British general hospitals, 741 were treated by primary suture and 192 by delayed primary suture.

In Italy in September and October 1944, 90 per cent of flesh wounds and 70 per cent of compound fractures amongst British and Indian personnel were treated by delayed primary suture. Under the direction of Brigadier Harold C. Edwards (1945), Captain C. Parish analysed the results of this wound closure in 3,845 of these patients. The results which are given in the accompanying Table demonstrate the success of this two-stage operation.

TABLE

RESULTS OF WOUND CLOSURE

	Delayed Primary Suture				Secondary Suture			
	Total	90–100 per cent healing	50–90 per cent healing	Failure	Total	90–100 per cent healing	50–90 per cent healing	Failure
All wounds	3,435	2,693 (78%)	537 (16%)	205 (6%)	410	276 (67%)	96 (24%)	38 (9%)
Compound fractures	429	311 (73%)	79 (18%)	39 (9%)	69	44 (64%)	20 (29%)	5 (7%)
Flesh wounds	3,006	2,382 (79%)	458 (15%)	166 (6%)	341	232 (68%)	76 (22%)	33 (10%)

BIBLIOGRAPHY AND REFERENCES

Edwards, H. C. (1945). *Lancet*, **1**, 583.
Lawrie, R. (1945). *Lancet*, **1**, 625.
Stammers, F. A. R. (1945). *Lancet*, **1**, 586.
Stout, T. D. M. (1946). *Aust. N.Z. J. Surg.*, **15**, 253.

[References to other titles are given under Gunshot Wounds and Allied Injuries (General Management) in the Index Volume.]

HAEMATOMA

By A. WALLIS KENDALL, M.S., F.R.C.S.
SURGEON, KING'S COLLEGE HOSPITAL; SURGEON, QUEEN ELIZABETH HOSPITAL FOR CHILDREN, LONDON

1. DEFINITION AND AETIOLOGY

175.] A haematoma is a swelling composed of blood which has extravasated into the tissues from injured blood-vessels. In a bruise or ecchymosis the injury has resulted in multiple small extravasations and there is no localization of the blood to a single fluid collection.

The amount of violence required to cause a haematoma varies not only between different tissues but also between individuals. From similar trauma, a young adult in good physical condition is much less likely to develop a haematoma than is a flabby, obese or elderly person. Apart from variations within normal limits some subjects are more liable to bleed freely after injury than are others, because of underlying pathological conditions. Thus the clotting of the blood is interfered with in jaundiced patients because of a deficiency in prothrombin. This can be corrected by giving vitamin K before any operative procedure. Again, in hereditary haemorrhagic states, as for example in haemophilia, a blow inflicted may be a slight one, but the amount of bleeding which follows may endanger the patient's life.

2. PATHOLOGY

The swelling, which at first is fluid, becomes solid from coagulation of the blood. This change occurs first at the periphery which becomes indurated, whilst the central part remains soft and fluctuant.

A haematoma may end in one of the following ways. *Outcome*

(1) A small haematoma is usually completely absorbed. Only partial absorption of a large haematoma may take place and the process is much slower.

(2) It may be converted into a mass of fibrous tissue—an "organized haematoma". If the haematoma is subperiosteal, a bony nodule may remain. On rare occasions heterotopic bone formation, in, for example, muscle or muscle sheath, takes place.

(3) It may become infected either by organisms circulating in the blood stream or introduced from without.

(4) Cyst formation may follow localized subdural haemorrhage. The cyst contains clear fluid and on its wall crystals of haematoidin or, less frequently, haematin, may be deposited.

Eller and Kest (1941) describe a case in which a sarcoma arose at the site of a haematoma in a man of 40 years of age who bumped his forehead.

3. CLINICAL FEATURES

(1) General

The general effects of a haematoma are produced in three ways as follows.

(1) Loss of blood in a large haematoma, such as that formed in the loose retroperitoneal tissue, causes symptoms of anaemia, the severity of which depends upon the amount of blood lost and the rate of the loss.

(2) Absorption of a haematoma causes a mild pyrexia. A leucocytosis is common and is particularly marked when blood is effused into the peritoneal cavity. The association of these two signs may cause suspicion of suppuration. There may be a slight tinge of jaundice.

(3) Suppuration causes toxaemic symptoms.

(2) Local

The local effects vary with the site and extent of the haematoma. Pain is severe if the tension is great, as, for example, in a subungual or a subfascial lesion. On the other hand, a subcutaneous effusion or one into lax connective tissue may cause little or no discomfort.

The site is, of course, important in other respects, and this could not be more strikingly illustrated than by an intracranial haematoma. This, whether extradural or subdural, is a *space-occupying lesion*, causing cerebral compression which, unless relieved, is likely to be fatal.

(3) Special sites

(a) Operation wounds

Infection of a "clean" surgical wound is preceded in a high percentage of cases by haematoma formation. The presence of an uncomplicated haematoma causes delay in healing, but following infection there is the added disadvantage of loss of normal tissue and replacement of it by weak scar tissue. The failure of a hernia repair operation, the development of an incisional ventral hernia and the formation of a thick, prominent and ugly scar may all in this way have their origin in a haematoma.

Prevention of haematoma formation

The prevention of haematoma formation is brought about by (*i*) haemostasis, (ii) space obliteration, and (iii) drainage.

Whereas effective haemostasis is important at all times, it is particularly so in operations for the repair of herniae and other defects in which the whole value of the operation would be destroyed by a failure to secure firm healing. *All* bleeding points should be ligated and the wound seen to be dry before closure. It should be remembered particularly that when an operation is done under spinal anaesthesia, there may be a considerable temporary fall of blood-pressure, and due allowance for this must be made.

Every effort must be made to suture the wound in such a way that a space does not remain in which blood can collect. The deeper parts of the wound

must be brought into apposition by suturing in layers. What are called "tension stitches" are used to achieve space obliteration in the deep subcutaneous fat rather than, as the name would seem to imply, to overcome the tendency of a wound to gape by the use of superior force. *Tension stitches*

When there is any doubt about haemostasis, drainage by means of a small tube or a piece of corrugated rubber must be provided until the risk of haematoma formation has disappeared. This is usually after 24 or 48 hours. It may be remarked that similar methods of drainage are used in anticipation of infection of wounds as, for example, of the abdominal wall after the removal of a grossly inflamed appendix. The object of the two types of drainage appears frequently to be confused, the latter being required for a longer period.

In certain wounds firm pressure can be brought to bear by strapping or bandaging, but in the former case complete sealing off of the wound with no allowance for aeration should be avoided. *Pressure*

A haematoma of an operation wound will appear as a swelling the long axis of which is in line with the incision. There will be increased tension on the skin sutures between which the skin itself is shiny and possibly discoloured. The swelling shows peripheral induration and, if large and recent, central fluctuation. The patient may complain of discomfort in the wound. The rise of temperature to 99°–100° F. which is usual on the day following operation will be repeated on the subsequent days. Events may be more dramatic, however, and the rapid formation of a haematoma after a partial thyroidectomy may call for the speediest intervention to relieve acute dyspnoea from pressure upon the trachea.

The differential diagnosis is usually to be made from infection, and abscess formation which it resembles to some extent. A haematoma is in its most fluid condition at its commencement, whereas an abscess forms at the end of a period of brawny induration. *Differential diagnosis*

In connexion with abdominal wounds there is one condition above all which must be differentiated from a haematoma, and this is a "burst abdomen" in which the deeper sutures only have given way. Although the patient may volunteer that he felt pain and something give way in his wound, the only physical sign at the commencement is the discharge of a little blood and serum from the wound. Depending upon the size of the separation of the wound deeply, a swelling, caused by the herniation of abdominal contents, may be seen. The smaller gaps are more serious than the larger because of the greater risk of strangulation of a knuckle of small intestine. To bear this possibility in mind is the most important step towards the correct diagnosis.

Unfortunately, the easier it is to diagnose the condition of affairs, the less vital is it to make the differentiation. If there is any doubt, surgical intervention is called for.

(*b*) *Muscle*

The muscle most frequently involved is the rectus abdominis, and the haematoma is associated with a partial rupture of its fibres. Strenuous muscular effort or a direct blow are the usual causes, but occasionally the degree of trauma is small. Strenger (1942) describes 3 cases of spontaneous haemorrhage into the muscle, in whom, at most, there may have been some slight strain from coughing. His patients were all over 60 years of age, therefore

degeneration of the muscle and blood-vessels may have been present. When the condition has followed adequate trauma, the diagnosis is not, as a rule, difficult. Pain followed by a palpable mass in the rectus are the important clinical features. The haematoma is usually subumbilical in position.

When the haematoma is a large one, operative treatment is advisable. Blood clot, which is mostly between the muscle and the posterior sheath, is evacuated and the ruptured muscle sutured with catgut.

(*c*) *Ear*

A blow on the ear may cause a haematoma between the perichondrium and the cartilage. Boxers are not unnaturally more affected than others, and to it they owe their deformed "cauliflower" ears. To avoid this complication, the clot should be evacuated without delay, through a small incision made under local anaesthesia.

(*d*) *Nail*

A subungual haematoma is a painful condition which may require treatment to relieve the tension. This may be achieved by aspiration, the needle being passed along immediately under the nail, or a small portion of the nail over the haematoma may be excised.

(*e*) *Scalp*

A haematoma of the subcutaneous tissue is always small and localized because of the large amount of fibrous tissue present in this layer. Blood effused under the sub-aponeurotic layer has wide limits, and may extend laterally between the zygomas and from the occiput to the eyelids. The scalp is raised off the skull by the large, boggy swelling. Infection of such a haematoma is rare, but when it does occur the risks are similar to those of infected wounds of this so-called "dangerous area". A collection of blood under the periosteum, called a cephalhaematoma, is caused occasionally by birth injury. The peripheral induration and central soft area of a haematoma may cause some difficulty in differentiating it from a depressed fracture of the skull. The edge is, however, compressible, and a depressed fracture after infancy is frequently compound.

Cephal-haematoma

A haematoma over the mastoid process may be present in fractures of the posterior fossa of the skull. A "safety-valve" haematoma may develop in children, following a fracture of the vault of the skull. The dura mater is firmly adherent to the vault in children, and becomes torn at the time of fracture of the skull. Any subdural haemorrhage taking place may gain an exit to the scalp and produce a haematoma which may prevent symptoms of cerebral compression for a time at all events.

4. TREATMENT

The objects of treatment are: (1) to prevent a haematoma increasing in size, (2) to relieve pain, (3) to minimize the risk of infection, and (4) to aid absorption.

(1) Pressure on a haematoma will cause pain unless provision is also made for drainage. If the haematoma is noticeably increasing in size, operative treatment is required to clear out the blood clot and arrest the bleeding.

(2) Pain is relieved at once by decreasing the tension by aspiration or incision. The extreme discomfort of a perianal haematoma, for example, is instantly removed by making a small incision, under local anaesthesia, and turning out the "black-currant jelly" clot.

(3) Most haematomas are liable to become infected, and the prophylactic use of sulphonamides is recommended.

(4) Small haematomas should be allowed to absorb spontaneously. The larger ones would take a long time to absorb, and the process should be aided by either aspiration or incision.

REFERENCES

Eller, J. J., and Kest, L. H. (1941). *Arch. Derm. Syph., N.Y.*, 43, 813.
Strenger, G. (1942). *Amer. J. Surg.*, 55, 594.

[References to other titles are given under Haematoma in the Index Volume.]

HAEMOPHILIA AND OTHER HAEMORRHAGIC STATES

By R. G. MACFARLANE, M.D.

Radcliffe Lecturer in Haematology, Oxford University; Clinical Pathologist, Radcliffe Infirmary, Oxford

1. DEFINITION

176.] The haemorrhagic states are those conditions in which the control of bleeding from damaged capillaries and minute vessels is so impaired that prolonged or even fatal haemorrhage may follow trivial injury.

2. PHYSIOLOGY OF HAEMOSTASIS

Normal haemostasis depends upon at least three factors: blood coagulation, the platelets and vascular contraction. Any derangement of these may cause abnormal bleeding.

(1) Blood coagulation

Formation of clot

Blood clotting involves the factors illustrated diagrammatically in Fig. 190, which react to produce ultimate fibrin formation. The fluid state of the blood in the vessels is due to lack of contact with a "foreign" (that is, water-wettable) surface, healthy vascular endothelium being inert. Contact with foreign surfaces activates the prokinase of the plasma, and the fluid from damaged tissues contains active kinase, so that trauma or removal from the body initiates coagulation. Normally, injuries or small areas of damaged endothelium do not cause widespread clotting in the vessels because of factors in the plasma antagonistic to clotting, but in static collections of blood in wound areas the generation of kinase and thrombin overwhelms the local concentration of anti-coagulant. Failure of clotting may result from (a) an excess of the natural anti-coagulants, (b) a deficiency of prothrombin or (c) a deficiency of fibrinogen.

Fig. 190.—The factors concerned in blood coagulation. Those in circles are present normally in the plasma, those in squares operate only during the process of clotting. Those in italics are probably enzymes. The solid arrows indicate the clotting process, the dotted arrows anti-coagulant activity. (*Proc. R. Soc. Med.*)

Subsidiary functions

Two subsidiary functions must also be noted. The first is retraction, the process by which newly formed clots shrink to about half their original volume, squeezing out serum and becoming considerably firmer in the process. The second is fibrinolysis, the process by which fibrin disintegrates after a few days in wound cavities or the tissues.

(2) The platelets

The platelets are normally present in the blood to the extent of 200,000-400,000 per cubic millimetre. They are derived from the megakaryocytes of the bone marrow, and may be reduced in number by a condition that depresses marrow activity. The platelets tend to become sticky on contact with a foreign surface, so that they agglutinate into masses.

(3) The blood-vessels

It is well known that the larger blood-vessels are contractile, but less familiar is the fact that the minute vessels are similarly active. The capillaries of the

HAEMOPHILIA AND OTHER HAEMORRHAGIC STATES

By R. G. MACFARLANE, M.D.
Radcliffe Lecturer in Haematology, Oxford University; Clinical Pathologist, Radcliffe Infirmary, Oxford

1. DEFINITION

176.] The haemorrhagic states are those conditions in which the ... *bleeding from damaged capillaries and minute vessels* ... prolonged or even fatal haemorrhage may follow trivial injury

2. PHYSIOLOGY OF HAEMOSTASIS

Normal haemostasis depends upon at least three factors: ... the platelets and vascular contraction. Any derangement of ... abnormal bleeding.

(1) Blood coagulation

Blood clotting involves the factors illustrated diagrammatically ... which react to produce ultimate fibrin formation. The ... in the vessels is due to lack of contact with a "foreign" (that is, water-wettable) surface, healthy vascular endothelium



skin can be seen to contract after puncture, to remain empty for about 30 minutes, and then to dilate, becoming refilled with blood.

(4) The probable mechanism of haemostasis

Blood clotting alone cannot control bleeding, since in certain haemorrhagic states coagulation is normal. Platelet agglutination also is not the sole factor involved, for similar reasons. It seems most likely that, after a short period of bleeding, haemostasis is due to the contraction of the damaged vessels, and that, during this contraction, the blood which escapes initially has time to clot firmly in the wound and so prevent the recurrence of bleeding when the vessels relax. While the platelets may be concerned with capillary contraction, the maintenance of vascular repair, blood coagulation and clot retraction, their exact part in the haemostatic mechanism is obscure.

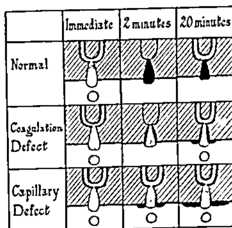


FIG. 191.—Diagram illustrating the time relationships of normal capillary contraction, dilatation and blood coagulation, and the two main defects that may occur. A wound of the skin surface is shown in section, injuring a capillary loop. Fluid blood is represented by the dotted areas, blood clot by solid black, and the detached drops indicate active haemorrhage. (*Proc. R. Soc. Med.*)

3. AETIOLOGY

The haemorrhagic states may therefore arise (1) from a defect of the clotting mechanism or (2) from a vascular defect. These abnormalities are illustrated diagrammatically in Fig. 191.

(1) Coagulation defects

The first group depends upon a failure to form a clot sufficiently firm to withstand the pressure in damaged vessels when they dilate after the initial period of contraction. In consequence, after a short interval there is prolonged bleeding from, or into, any part of the body in which vessels have been ruptured. As will be seen from Table I, these clotting defects may be inherited, congenital, acquired or secondary to some other disease. Haemophilia is the most familiar of the hereditary states, and depends upon a delay in clotting possibly due to excess anti-kinase. Its sex-linked recessive transmission accounts for the fact that only males bleed abnormally, and only females pass the condition to their children. It must be remembered, however, that the daughter of a haemophiliac may have affected sons.

Fibrinopenia may occur as an inherited condition, or secondary to liver disease; both are very rare.

Hypoprothrombinaemia is most commonly due to the failure to absorb vitamin K, (1) in the absence of bile salts that follows obstructive jaundice; (2) in intestinal hurry and in sprue. Haemorrhagic disease of the new-born is due to congenital vitamin K deficiency. Liver disease may result in a failure to produce prothrombin, even if the vitamin K absorption is adequate.

Excessive fibrinolysis occurs rarely as an essential abnormality and much

more frequently as a result of proteolysis due to local sepsis, when it becomes a cause of so-called "secondary haemorrhage".

TABLE I

THE HAEMORRHAGIC STATES ARISING FROM DEFECTIVE BLOOD COAGULATION

Haemostatic Defect	Condition	Variety	Probable Aetiology
Coagulation defect	Haemophilia	Haemophilia	Hereditary (sex-linked recessive)
		Pseudo-haemophilia	Abnormal globulins, myelomatosis, Hodgkin's disease and idiopathic
	Hypoprothrombinaemia	Haemorrhagic disease of the new-born	Congenital vitamin K deficiency
		Haemorrhagic jaundice	Mal-absorption of vitamin K
		Sprue	Mal-absorption of vitamin K
		Liver disease	Mal-production of prothrombin
	Fibrinopenia	Essential	Hereditary (recessive)
		Symptomatic	Liver disease
	Fibrinolysis	Essential (purpura thrombolytica)	Unknown
		Symptomatic	Local sepsis

(2) Vascular defects

There are two distinct but often coexistent vascular defects associated with the haemorrhagic states. The first is a simple increase in capillary fragility, or purpura simplex. The minute vessels are less able to withstand pressure than are normal capillaries, and in consequence easy bruising and spontaneous purpuric haemorrhages into the skin or mucous membrane may occur. *Purpura simplex*

The second, probably due to loss of capillary contraction, causes a tendency to bleed persistently from minute injuries such as needle punctures, from apparently intact mucous membranes, or into the superficial tissues, resulting in the condition of " purpura haemorrhagica".

Either or both of these conditions may be secondary to a variety of toxaemias and other states as shown in Table II.

There is usually in purpura haemorrhagica a marked reduction in the platelets (thrombocytopenia), but this is not invariable. *Purpura haemorrhagica*

The aetiology of essential thrombocytopenic purpura is obscure. It involves the spleen in some way, since splenectomy may cure the condition. Essential athrombocytopenic purpura is apparently due to an inherited abnormality of the capillaries. Telangiectasia is an inherited defect which results in localized collections of dilated and non-contractile capillaries.

skin can be seen to contract after puncture, to remain empty for about 30 minutes, and then to dilate, becoming refilled with blood.

(4) The probable mechanism of haemostasis

Blood clotting alone cannot control bleeding, since in certain haemorrhagic states coagulation is normal. Platelet agglutination also is not the sole factor involved, for similar reasons. It seems most likely that, after a short period of bleeding, haemostasis is due to the contraction of the damaged vessels, and that, during this contraction, the blood which escapes initially has time to clot firmly in the wound and so prevent the recurrence of bleeding when the vessels relax. While the platelets may be concerned with capillary contraction, the maintenance of vascular repair, blood coagulation and clot retraction, their exact part in the haemostatic mechanism is obscure.

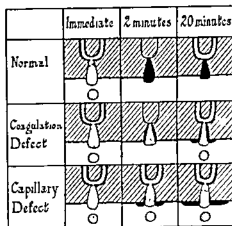


FIG. 191.—Diagram illustrating the time relationships of normal capillary contraction, dilatation and blood coagulation, and the two main defects that may occur. A wound of the skin surface is shown in section, injuring a capillary loop. Fluid blood is represented by the dotted areas, blood clot by solid black, and the detached drops indicate active haemorrhage. (*Proc. R. Soc. Med.*)

3. AETIOLOGY

The haemorrhagic states may therefore arise (1) from a defect of the clotting mechanism or (2) from a vascular defect. These abnormalities are illustrated diagrammatically in Fig. 191.

(1) Coagulation defects

The first group depends upon a failure to form a clot sufficiently firm to withstand the pressure in damaged vessels when they dilate after the initial period of contraction. In consequence, after a short interval there is prolonged bleeding from, or into, any part of the body in which vessels have been ruptured. As will be seen from Table I, these clotting defects may be inherited, congenital, acquired or secondary to some other disease. Haemophilia is the most familiar of the hereditary states, and depends upon a delay in clotting possibly due to excess anti-kinase. Its sex-linked recessive transmission accounts for the fact that only males bleed abnormally, and only females pass the condition to their children. It must be remembered, however, that the daughter of a haemophiliac may have affected sons.

Fibrinopenia may occur as an inherited condition, or secondary to liver disease; both are very rare.

Hypoprothrombinaemia is most commonly due to the failure to absorb vitamin K, (1) in the absence of bile salts that follows obstructive jaundice; (2) in intestinal hurry and in sprue. Haemorrhagic disease of the new-born is due to congenital vitamin K deficiency. Liver disease may result in a failure to produce prothrombin, even if the vitamin K absorption is adequate.

Excessive fibrinolysis occurs rarely as an essential abnormality and much

destruction of interstitial blood. More special effects frequently seen in haemophilia are as follows. *Special manifestation*

(*a*) *The muscles*

Bleeding into or around muscles causes loss of function and sometimes pressure ischaemia leading to permanent damage and contractures.

(*b*) *The nervous system*

There may be pressure on any of the peripheral nerves with more or less permanent loss of function. Haemorrhages into the central nervous system may occur.



Fig. 192.—Sagittal section through the tongue and larynx showing the massive haemorrhage into the tissues that led to fatal asphyxia in a case of haemophilia.



Fig. 193.—Sagittal section through a knee joint showing the blood-filled cavity and destruction of the articular cartilages following haemarthrosis in a case of haemophilia.

(*c*) *The respiratory system*

Haemorrhages into the tissues of the mouth, tongue, throat or mediastinum are liable to impede respiration, and have been the cause of several cases of fatal asphyxia (Fig. 192).

(*d*) *The joints*

Repeated haemarthroses are characteristic of haemophilia. They arise as a result of minor injuries and occur with greater frequency as the structures are destroyed and stability is impaired. The knee, ankle, elbow, hip, wrist and

TABLE II

THE HAEMORRHAGIC STATES ARISING FROM ABNORMALITIES OF THE CAPILLARIES AND MINUTE VESSELS

HAEMOSTATIC DEFECT	CONDITION	VARIETY	PROBABLE AETIOLOGY
Decreased capillary resistance	Purpura *simplex*	Schönlein-Henoch	Allergy
		Scurvy	Vitamin C deficiency
		Toxic	Acute fevers and infections, drugs and poisons
		Metabolic	Malignancy, senility, hormonal
Decreased capillary contractibility	Thrombo-cytopenic purpura haemorrhagica	Essential (Werlhof's disease)	Splenopathic Occasionally hereditary
		Symptomatic	Acute fevers, infections, drugs, poisons, aplastic anaemias, leukaemias, generalized malignant disease
	*Athrombo-*cytopenic *purpura* haemorrhagica	Essential (*Glantzman's* disease)	*Hereditary (simple dominant)*
		Symptomatic (*rare*)	Vitamin K deficiency, toxaemias, *uraemia*
	Telangiectasia	*Essential* (Osler's disease)	Hereditary (simple dominant)
		Symptomatic	Liver disease, pregnancy

4. PATHOLOGY

(1) Essential pathology

No primary abnormalities can be demonstrated in the essential haemorrhagic states, with the exception of the capillary lesions found principally on the lips, face and fingers, and in the nose and occasionally in the bronchi, stomach, colon and urinary tract in haemorrhagic telangiectasia.

(2) The direct effect of blood loss

Bleeding in these states is usually slow but prolonged. In consequence, the patient becomes gradually exsanguinated, shows the signs and symptoms of post-haemorrhagic anaemia and may, if treatment is unavailing, finally die.

(3) The effect of haemorrhage into the tissues

In cases of defective coagulation, extensive bleeding into any of the tissues may occur, causing local pain, tenderness and inflammation. In more superficial areas, discoloration of the skin occurs, but this may be absent if the haemorrhage is deep-seated. There may be elevation of temperature and pulse, a leucocytosis and, in some cases, definite jaundice from rapid

(3) Acquired hypoprothrombinaemia

In obstructive jaundice, sprue or severe liver disease, there may be a dangerously low level of prothrombin with little clinical indication apart from a tendency to form subcutaneous or deep haematomas. After injury or operation, however, uncontrollable bleeding may begin, reducing the blood-prothrombin content still further, so that a generalized haemorrhagic diathesis may develop.

(4) Fibrinopenia

This condition is clinically indistinguishable from haemophilia.

(5) The purpuras

(a) Purpura simplex

This is indicated by the spontaneous appearance of petechial haemorrhages in the skin and mucous membranes without prolonged bleeding from injuries. It is often symptomatic of mild capillary damage that occurs in acute infections, fevers, drug intoxications or metabolic disorders. It may be the presenting sign in scurvy. A variety probably associated with allergy is Schönlein-Henoch purpura, in which swelling of the joints, urticaria, petechial haemorrhages, haematemesis and melaena may all occur, often preceded by a sore throat or other infection, or a gastro-intestinal disturbance.

Schönlein-Henoch purpura



FIG. 196.—Secondary purpura haemorrhagica in a case of acute leukaemia.

(b) Purpura haemorrhagica

Purpura haemorrhagica, essential or secondary, is characterized by prolonged haemorrhage from slight injuries, bleeding into the skin, varying from petechiae to large ecchymoses (Fig. 196), and by oozing of blood from the mucous membranes of the nose, mouth, gastro-intestinal and uro-genital tracts. The bleeding tendency may be localized in some cases, epistaxis or menorrhagia being the only major symptoms. Deep tissue haemorrhages are very rare, and haemarthrosis is scarcely known, but there is serious risk of intracranial bleeding. In secondary purpura haemorrhagica, which indicates severe capillary damage, these symptoms complicate severe infections and fevers, and the terminal phases of the leukaemias and aplastic anaemias.

Athrombocytopenic purpura

In athrombocytopenic purpura the picture is very similar to the thrombocytopenic variety, except that the bleeding tendency is chronic and begins in early childhood. There is usually a history of similar bleeding in the family.

(6) Telangiectasia

In this condition, an adult, in other respects usually quite normal, develops small red spots, that disappear on pressure, on the lips, face, fingers, and in

shoulder are the most frequently affected, in that order, but any joint may be the seat of bleeding. Haemorrhages occur into the joint space, the peri-synovial tissues or into the bone itself, resulting in progressive ankylosis and crippling destruction (Figs. 193, 194 and 195). These haemarthroses are accompanied by great pain, local swelling and general constitutional symptoms, and are probably the most distressing manifestation of haemophilia.

5. CLINICAL PICTURE

(1) Haemophilia

The patient is a male, except in the extremely rare cases of pseudo-haemophilia. There is a history of repeated haemorrhages from injuries of the skin or mucous membranes, epistaxis, haematuria and extensive haematomas



FIG. 194.—Skiagram of a haemophilic knee joint showing narrowing of the joint space and irregularity of the articular surfaces.



FIG. 195.—Skiagram of a haemophilic elbow showing total disorganization of the joint.

resulting in painful swellings of the deep tissues and joints. External loss of blood may continue until the patient is white and exhausted. Internal bleeding is accompanied by pain, fever, anaemia and constitutional disturbances. One or more limbs may be wasted, the joints enlarged and with limited movement, complete ankylosis, or loss of stability. The tendency to bleed usually begins during the second or third year of life and may, in some cases, show a cyclical variation in severity.

(2) Congenital hypoprothrombinaemia (haemorrhagic disease of the new-born)

In this condition an otherwise healthy baby during the first day or so after birth suddenly begins to vomit blood and to bleed per rectum and from the cord. There may be spontaneous bruising and, in severe cases, oozing from the mucous membranes.

7. DIFFERENTIAL DIAGNOSIS

The existence of haemorrhagic diathesis is usually obvious, but certain manifestations may be confusing.

(1) In haemophilia, haemarthrosis may be mistaken for infection, and retroperitoneal or intraperitoneal haemorrhage may simulate acute abdominal conditions. Once the diagnosis of haemophilia is made, the probability of haemorrhage being the cause of the local condition will be realized. *Haemarthros*

(2) In Schönlein-Henoch purpura in children, abdominal pain and passage of blood per rectum may suggest intussusception. The presence of allergic or purpuric manifestations should suggest the right diagnosis. Occasionally, however, a submucous haematoma in this condition may start an actual intussusception. *Schönlein-Henoch purpura*

(3) The distinction between essential and secondary thrombocytopenic purpura may sometimes be difficult, requiring a complete haematological investigation. *Thrombocytopenic purpura*

8. PROGNOSIS

(1) Haemophilia and the other inherited haemorrhagic states are, at present, incurable. Treatment is symptomatic and the liability to excessive bleeding persists throughout the patient's life. There is a tendency (except in hereditary telangiectasia) for the condition to moderate as the patient grows older, so that in middle or late adult life, if this is achieved, a comparatively normal existence is sometimes possible. Many cases terminate in childhood from the direct effects of haemorrhage.

(2) Hypoprothrombinaemia, when due to vitamin K deficiency, is easily and rapidly cured by appropriate treatment. When due to liver disease, however, the prognosis is more gloomy.

(3) Purpura secondary to toxaemias and infections usually clears up as these conditions subside, but when complicating leukaemia, aplastic anaemia and malignancy it frequently indicates a rapidly fatal outcome.

(4) Essential thrombocytopenic purpura runs an erratic and recurrent course if untreated. Spontaneous recovery is rare in adults but frequent in children.

9. INDICATIONS FOR SURGICAL INTERVENTION

No patient with a severe generalized haemorrhagic state should be subjected to surgical operation, with the exception of essential thrombocytopenic purpura in which splenectomy is indicated, and of those cases in which it is certain that the patient will die unless an operation is performed. Surgical treatment of traumatic injuries should involve the minimum of interference. Obvious bleeding points can be ligated, but, in haemophilia, wounds must be left open or internal bleeding will result.

10. TREATMENT

(1) Haemophilia

(a) External bleeding

Accessible bleeding can usually be controlled by the application of an effective coagulant such as Russell's viper venom (Stypven) or Thrombin Coagulant. *Coagulant*

the nose and mouth. Prolonged bleeding follows traumatic or spontaneous rupture of the dilated capillaries forming these telangiectases. Epistaxis occurs most frequently and may even be fatal. The external lesions may bleed persistently if injured. There may be recurrent haematemesis, haemoptysis or haematuria, without other symptoms, and sometimes without external lesions being visible. There is usually a strong family history, except in the symptomatic variety.

TABLE III

THE RESULTS OF INVESTIGATION OF THE HAEMOSTATIC MECHANISM IN VARIOUS HAEMORRHAGIC STATES

CONDITION	CLOTTING TIME	PROTHROMBIN TIME	CLOT RETRACTION	BLEEDING TIME	PLATELET COUNT	CAPILLARY RESISTANCE	CAPILLARY CONTRACTION
Haemophilia	Long	Normal	Normal	Normal	Normal	Normal	Normal
Hypoprothrombinaemia	*Normal* or Long	Long	*Normal* or Low	*Normal* or Long	Normal	Normal	Normal
Fibrinopenia	Infinitely long	Normal[1]	Normal[2]	Normal	*Normal* or Low	Normal	Normal
Purpura simplex	Normal	Normal	Normal	Normal	Normal	Reduced	Normal
Thrombocytopenic purpura	*Normal*	*Normal*	Reduced	*Long*	*Low*	Reduced	Reduced
Athrombocytopenic purpura	Normal	*Normal*	*Normal*	*Long*	*Normal*	Reduced	Reduced
Telangiectasia	Normal	Normal	Normal	Normal[3]	Normal	Normal	Normal[4]

Notes: (1) and (2) These investigations require the addition of fibrinogen to the blood examined

[3] The bleeding time is normal in telangiectasia if the lesions are avoided. If an affected capillary is punctured, however, prolonged bleeding occurs.

[4] Affected capillaries do not contract.

6. DIAGNOSIS

The diagnosis of these conditions depends upon (1) the characteristic history, (2) the family history and mode of inheritance, (3) physical examination, which may reveal the changes already described, and (4) investigation of the haemostatic mechanism, which involves the following estimations: the coagulation and prothrombin times; clot retraction; capillary resistance; the bleeding time, which probably depends upon the efficiency of capillary contraction; the platelet count and, for research purposes, microscopical observation of capillary contraction after injury. Typical findings in the various haemorrhagic states are given in Table III. Details of technique can be found in text-books of haematology.

(b) *General*

In essential thrombocytopenic purpura, if it has been decided that spontaneous cure is unlikely to occur, splenectomy is the treatment of choice. In about 70 per cent of cases, splenectomy results in a clinical cure, though in about half of these thrombocytopenia returns or persists after operation. Failure is often due to an unsuspected splenunculus. In successful cases bleeding stops rapidly after the spleen is removed, sometimes even while the patient is still on the operating table. It is advisable, however, to give a transfusion of fresh blood immediately before the operation and to be prepared to repeat this afterwards. Local applications are useless. *Splenectomy*

In cases of severe menorrhagia in which splenectomy is contra-indicated, or has failed, an artificial menopause may be necessary.

The treatment of the secondary purpuras is symptomatic, the underlying condition requiring the major attention.

(5) Athrombocytopenic purpura

This does not respond to splenectomy. Accessible haemorrhages can be controlled by pressure. Blood transfusions or an artificial menopause may be required in severe cases.

(6) Haemorrhagic telangiectasia

The bleeding from accessible telangiectases can be controlled by pressure. An inflatable rubber bag may be used with success to control the severe epistaxis which is often the major symptom. Cauterization of individual lesions or treatment with radium is sometimes successful, but the condition is apt to recur.

BIBLIOGRAPY

Birch, C. La F. (1937). *Hemophilia; Clinical and Genetic Aspects.* Urbana, Ill.; University of Illinois Press.

Macfarlane, R. G. (1941). *Quart. J. Med.*, 10, 1.

— (1945). *Proc. R. Soc. Med.*, 38, 399.

Quick, A. J. (1942). *The Haemorrhagic Diseases and the Physiology of Hemostasis.* Springfield, Ill.; Thomas.

[References to other titles are given under Haemophilia and Other Haemorrhagic States in the Index Volume. The subjects of Haemophilia and of Haemorrhagic Diseases are also dealt with under the headings of Haemophilia, and Haemorrhagic Diseases in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, pp. 123 and 138.]

After useless clots have been removed the coagulant should be applied to the bleeding area on gauze, or better, on fibrin foam (Lister Institute). The haemostatic dressing must be held firmly in place by digital pressure applied for about 5 minutes, so that firm coagulation can take place. The clots so formed will then maintain haemostasis when pressure is removed, until fibrinolysis or mechanical movement causes their detachment. In the mouth, particularly in the case of bleeding from tooth sockets, a dental splint to keep the dressing in place may be required. Bleeding may restart in 12–24 hours, when re-dressing will be necessary. It is important to avoid devitalizing the tissues by tight plugging, suturing or undue pressure. Healing must be encouraged as much as possible, but mere mechanical closure of the superficial parts of a wound may lead to dangerous bleeding into the deep tissues.

(*b*) *Internal bleeding*

Rest and blood transfusion

Bleeding into the tissues may cause serious blood loss, and pressure on vital structures. It should be treated by rest in bed, and by blood transfusion if necessary. If a limb is affected it should be elevated and immobilized. Haemarthroses should be treated in the same way, splints being used if required. When the swelling subsides, massage and passive movements should be applied to restore function as much as possible. Some good results have been obtained by washing out joints during the acute stage, but this requires the greatest care and is not to be recommended for general use. Haematuria may persist for weeks and require repeated transfusion. It may be necessary to pass a laryngeal tube in cases of bleeding into the tissues of the mouth or throat.

(*c*) *General*

Transfusion of fresh blood not only makes good that lost by haemorrhage, but improves the clotting function. The effect varies in degree and duration, but is usually quite marked and capable of controlling internal haemorrhage. Recent work suggests that the particular blood fraction responsible for this improvement may soon be isolated and become available for injection, when small, repeated doses may be sufficient to keep the patient in reasonable health.

Many other forms of treatment have been enthusiastically recommended, but all have failed to establish themselves.

(2) Fibrinopenia

Fibrinopenia must be treated symptomatically by transfusion and by local applications of fibrin or fibrinogen.

(3) Hypoprothrombinaemia

Hypoprothrombinaemia, except that due to liver failure, can be alleviated by adequate dosage with vitamin K, given by injection in severe cases. If dangerous bleeding is already occurring, transfusions of fresh, normal blood should also be given.

(4) Thrombocytopenic purpura

(*a*) *Local*

Bleeding from small lesions such as needle punctures or scratches can be stopped by simple pressure applied for 5 minutes. Blood clotting is normal in these cases, and during the period of pressure a firm clot can form.

before the onset of serious bleeding. When seen they are of value in forewarning the surgeon, but it should be noted that they may not occur, or when they do, they do not give any indication of the severity of the secondary haemorrhage, should this take place.

3. CLINICAL PICTURE

The clinical picture may be conveniently divided into local and general. *Local* The escaping blood may come from an artery, vein or capillary. When there is no breach of a surface the clinical appearance may be that of a bruise. The patient complains of some pain and marked tenderness. A bigger and localized accumulation of blood or haematoma appears as a fairly circumscribed painful and tender swelling, often with overlying bruising of the skin. In some sites, for example in the scalp, the centre of the haematoma is fluctuant, and the periphery firm and pitting. If the haemorrhage is from a large vessel and especially from an artery, the haematoma enlarges rapidly and may exhibit pulsation. The rapid enlargement causes intense pain by virtue of the rise in tension, which in a limb may be sufficient to interfere with the distal circulation.

The general symptoms and signs of haemorrhage are of importance in mak- *General* ing a diagnosis of concealed bleeding, and in estimating the quantity of blood lost and the effect on the patient. The clinical results depend not only upon the quantity lost, but upon the rate at which this loss occurs. In the early stages of bleeding, or when the total loss is small, the patient may just feel giddy and faint; he may complain of flashes of light before his eyes; he will look pale and the pulse will be somewhat raised and of a lessened volume. Provided the total loss does not exceed 10 per cent, the body is able to recover rapidly.

When the loss is severe, rapid and continued, the picture is different. The patient is prostrate and looks extremely pale. His skin is cold and clammy from compensatory vasoconstriction. The mucous membranes are anaemic, and so is the conjunctiva. The pulse at the wrist is rapid and of low tension, later becoming what is often termed "thready", and finally, in severe loss, imperceptible, when evidence of circulatory life has to be listened for at the apex beat with a stethoscope. The blood-pressure will show a rapid fall of systolic and diastolic pressure, and finally no reading can be made. The increase in heart rate is reflex consequent upon a fall in blood-pressure, and probably upon other factors.

The respirations are increased in depth due to anoxaemia of the respiratory centre. This, together with the faster heart beat, is an attempt to increase the load of oxygen delivered to the anoxaemic tissues. In the later stages the respirations become longer and deeper, sighing in character, and are aptly described as air hunger. In the final stages when the respiratory centre is *Air hunger* failing the respiration becomes periodic and gasping, at the onset of impending death.

The patient suffering from pure loss of blood is restless. His loss of fluid makes him very thirsty. The body temperature is subnormal due to the skin vasoconstriction and fluid loss. It should be noted, however, that in some cases of internal haemorrhages into a body cavity where the products may be absorbed, as in duodenal haemorrhage, the temperature may be raised to

HAEMORRHAGE

BY R. H. BOGGON, M.S., F.R.C.S.
SURGEON, ST. THOMAS'S HOSPITAL, LONDON

1. DEFINITION AND AETIOLOGY

177.] Haemorrhage is described as the escape of blood from a ruptured vessel. Although the rupture can be caused by disease, in surgery and for the purposes of this article it follows injury. The trauma may be accidental or unavoidably deliberate as in operations.

2. TYPES

Primary Primary haemorrhage is the loss immediately following damage to a vessel, and this continues until it stops by natural processes or until deliberate steps are taken to control it.

Reactionary Reactionary or intermediate haemorrhage follows the cessation of the primary bleeding at an interval of hours. It is usually seen in the 24-hour post-operative period and may be brought on by numerous causes. An improvement in the patient's blood-pressure may eject the clot from the opening in the wounded vessel. Ligatures, especially catgut ones, may slip off or knots untie, even when tied with care. Restlessness in a recovering patient may disturb clot or ligatures. The opening up of a collateral circulation may lead to a haemorrhage from the distal untied end of a divided vessel. Another probable cause is bleeding from a lateral hole in an artery or vein when normal circulatory conditions are restored.

Secondary Secondary haemorrhage is brought on by sepsis. Infection delays or prevents healing in all tissues. In divided vessels, the septic process may dissolve clot, prevent granulation tissue organizing, or if intense, result in damage or sloughing of the vessel wall. The time required for these changes to occur depends upon a losing balance between the virulence of infection and the resistance of tissue. It is measured in days, and 10 is about an average. "Warning haemorrhages" in the form of small quantities of bright blood, often in increasing amounts, may be noticed on the dressings for a day or two

in the orifice, and around the vessel. The external clot, limited in many cases by tissue planes, will mechanically press upon the vessel wall and may assist in controlling the bleeding. When a vessel is roughly torn across there is less severe haemorrhage, owing to greater tissue damage, than when a similar vessel is cut cleanly across with a sharp knife.

Another factor in producing temporary control is the general lowering of blood-pressure, especially in arterial haemorrhage. In venous bleeding the drop in pressure is slight as the loss is usually more gradual. This fall in pressure appears to be reflex following a sudden appreciable loss and is associated with a diminished cardiac output. A lowered blood-pressure has the effect immediately of lessening the loss and also of not embarrassing the attempts already mentioned in blocking the outlet. Later, with the absorption of fluid from the tissue into the circulation the blood-pressure will rise, but any harm this may do to natural arrest may be offset by the increase in the quantity of fibrinogen made available.

There are a number of circumstances in which this natural arrest is hindered. For instance, a vessel not divided across completely will go on bleeding, as the impediment to contraction and retraction of muscle fibres prevents closure of the opening. In the scalp, the vessels are held open by fibrous attachments to the skin and the underlying aponeurosis, so that quite apart from the vascularity of the area the loss is disproportionate. Local movements, for example due to inadequate splinting, may aggravate haemorrhage. General stimulation of the body by general movement or by the use of stimulating drugs or by attempts at premature resuscitation will, by raising the blood-pressure, increase the loss of blood. Finally, in certain blood diseases in which the normal processes of coagulation do not occur the control of haemorrhage is difficult or well-nigh impossible. The permanent arrest is brought about by the ordinary process of repair in soft tissues. *Permanent arrest*

7. PREVENTION OF HAEMORRHAGE

The loss of blood in surgery can be lessened by attention to certain details. The general health of the patient should be improved, and a blood transfusion given when the haemoglobin is much below normal. A jaundiced person is likely to bleed unduly, as the absence of bile salts in the intestine prevents the absorption of vitamin K, and this results in a prothrombin deficiency: vitamin K should therefore be given.

At operation, congestion should be avoided, and a quiet and suitable anaesthetic with adequate oxygenation is required. A practical knowledge of the exact position of the smaller vessels will help a skilled operator to avoid them. When bleeding is likely to be serious preliminary ligation of a main vessel may be advisable. Finally, delay in securing all bleeding points during operations is to be avoided.

8. TREATMENT

(1) Immediate control

Haemorrhage always requires prompt treatment, as life may be at stake. The principle of immediate control is to apply pressure to occlude the vessel or obstruct the hole in it. Such pressure need only be just greater than the local intravascular pressure. The practical application of this depends upon prevailing conditions and the anatomical locality.

between 99° and 100° F. for a few days. Some patients complain of temporary loss of vision and others vomit. The pupils are dilated.

In the final stage, there is loss of consciousness, respiratory and circulatory failure rapidly leading to death.

4. DIFFERENTIAL DIAGNOSIS

The main differential diagnosis is from pure shock. Haemorrhage and shock are not synonymous terms. Pure haemorrhage does not cause pure shock, although haemorrhage aggravates the state of shock. Following severe injuries there is a shock-haemorrhage combination, and it is difficult to assess the relative importance of each. Although clinically the two conditions may appear the same, there are distinct differences. Following a gross loss of blood the patient suffers from air hunger, is restless and his haemoglobin content is lessened, consequent upon the blood loss, and the absorption of tissue fluid into the circulation in an attempt to restore the volume of circulating blood. A severely shocked person, on the other hand, is quiet and apathetic, does not suffer from air hunger and may have peripheral cyanosis. If his blood is examined the red-cell count is raised, the haemoglobin percentage increased and the viscosity is greater, following a loss of plasma into the tissues.

5. PROGNOSIS

In the normal adult the prognosis depends upon a combination of two factors, the quantity of blood lost and the rate of that loss. A slight loss recurring steadily over a period will pass unsuspected for some time, until the clinical picture of chronic anaemia becomes obvious. A rapid loss from a large vessel on the other hand produces general symptoms and signs in a few minutes. A primary loss of 3–4 pints can be recovered from, but subsequent bleeding shortly afterwards, even of a small quantity, will produce an alarming change. The outlook is also bad when the patient is suffering from shock, is dehydrated or is debilitated. The aged react badly to bleeding and recover slowly from its effects in spite of treatment. Children are also affected adversely, but, once the haemorrhage is stopped, recover rapidly.

6. NATURAL ARREST OF HAEMORRHAGE

There is a natural mechanism for the arrest of bleeding. This mechanism depends upon a number of factors, and is designed to produce a rapid but temporary sealing off of the escape point, to be followed by a more solid and permanent closure of the hole.

Temporary control

When an artery is cut or torn across, there is an attempt on the part of the vessel to close the opening. The inner coat or intima curls up into the lumen and so diminishes the diameter, or sometimes blocks it. External to this, the muscle fibres of the middle coat support the attempt of the intima to block the lumen by first contracting and then retracting their fibres.

The next point is *the tendency for free blood to clot. One of the main factors* in blood coagulation is the contact of the blood with damaged tissues when the thrombokinase found there will, with the assistance of calcium salts, convert the prothrombin present in the blood into thrombin, which then converts the fibrinogen into fibrin. The clot formed will lie inside the lumen,

forceps or an equally useful modification. A ligature is then passed around the forceps, and the first hitch tied firmly, after which, the forceps is released and a reef knot completed. Absorbable catgut is most generally used, but unless applied carefully may become loose or untied. Silk or thread obviate this, and are becoming increasingly popular. When a thick vascular pedicle is being dealt with it is wise to transfix the pedicle with a suture before tying, and sufficient tissue is left distal to it to prevent its sliding off. It is important to remember that both ends of a divided artery may bleed and therefore both ends require tying. A lateral hole in a large vein can be closed with a lateral ligature, but in other cases it is best to divide the vessel across and ligate.

Stitches are often used to underrun and compress vessels, for example in the intestines and scalp, when they act as sutures in addition. The isolation of an artery and the passage of two ligatures around it by means of an aneurysm needle is often employed. It is important to see that the two ligatures are not close together, as they may slip off when the vessel is cut across.

Heat

Heat can be used to seal off bleeding points. The electric cautery and the Paquelin cautery are employed at a dull red heat, but where available, a surgical diathermy machine set for a coagulating current is a more valuable method of closing off a number of vessels rapidly. A large flat electrode is attached either to the thigh or sacral area. The other electrode is in the form of a needle or small button, and when the current is switched on this electrode is made to touch each artery forceps in turn. It is important to make sure that the only part of the artery forceps in contact with the patient during this manoeuvre is the point controlling the bleeding vessel.

In capillary oozing, normal saline solution applied on gauze packs at 115° F. is all that is required. Often in this form of haemorrhage, light pressure patiently applied for 5 minutes will control it adequately. Torsion, that is the gripping of a vessel with an artery forceps, and rotating the forceps 8–10 times and then releasing it, will seal up quite large vessels. In certain areas special methods of control are required, for example, in intracranial surgery tiny silver V-shaped clips are placed astride vessels, and when compressed with suitable forceps cause occlusion. In some places, bleeding points which cannot be stopped by other means may be dealt with by applying small portions of muscle, preferably crushed, in the form of a graft. In practice chemical styptics such as ferric chloride, adrenaline and turpentine are disappointing, but occasionally the local application of snake venom such as Russell viper venom, 1:10,000, is effective.

Special methods

(3) Treatment of concealed haemorrhage

In most cases, circumstances prevent the easy location and securing of the bleeding point. Reliance has to be placed upon natural arrest, and the surgeon's task is to assist this. The patient is kept completely at rest and morphine in big doses is given. Fluids, in sufficient quantities to raise the blood-pressure, should not be given, but in severe loss whole blood may be required as a vital replacement, the quantity and rate of replacement being governed by the clinical state. Rapid deterioration of the patient's condition indicating progressive loss may require operative intervention, for example in bleeding from a lacerated spleen. In other cases the escaped blood, as in middle meningeal haemorrhage, may collect and cause such pressure effects that surgical relief is required to save life. Once concealed bleeding has ceased, the disposal of

First aid

Fortunately, in accidental wounds simple pressure applied by means of a pad or clean handkerchief with a bandage or binder is sufficient. Penetrating wounds of the trunk involving large vessels can only be dealt with by quieting the body with morphine and giving a blood transfusion until the site of the bleeding can be reached surgically. In some cases where local pressure is not completely successful, digital pressure on the main vessel to the area is required. The tourniquet, although decried as a result of recent war experience, can be used intelligently. It should only be applied sufficiently tightly to control the bleeding, and should not be left on longer than 40 minutes. The Samway rubber tube tourniquet and the Esmarch rubber bandage are most commonly employed, but the pneumatic tourniquet in the form of sphygmomanometer cuff is the most accurate and least traumatic method of application.

Haemorrhage during operations

During operations, however careful the surgeon, haemorrhage sudden, unexpected, and severe may occur. Such bleeding requires immediate attention and may tax the skill, courage, and ingenuity of the operator to a high degree. Any flurry or lack of self-control may place the patient in jeopardy. It is impossible here to describe all the methods of stopping such bleeding, but a general indication of procedure is given.

In an open wound, spurting from an artery may show where an artery forceps can be applied accurately. With torrential haemorrhage the blood obscures the field, and the loss rapidly affects the patient's general condition. Plunging an artery forceps blindly and deeply into a wound may not only be ineffectual, but do untold damage. Pressure applied with the thumb or finger against bony counterpressure will usually control matters temporarily. It is the accuracy of application and not the degree of pressure which counts. If this fails, then it is wisest to pack the wound with gauze packs so that sufficient pressure is diffused equally throughout the area. Assuming the bleeding is stopped, then it is advisable to wait some minutes before cautiously removing the packing, when as a result of the natural process of arrest the flow will have diminished, so that securing the bleeding point is relatively simple. In other cases a trustworthy and powerful sucker will remove the blood as rapidly as it escapes, when the damaged vessel can be seen and dealt with. In venous haemorrhage from a large vessel, especially in the neck, care should be taken to prevent an air embolus, either by packing the wound immediately or filling it with warm saline. Occasionally, when for some reason a ligature cannot be got round an applied artery forceps, it is best to leave the forceps on with the handles, suitably protected, sticking out of the wound. Removal 4–6 days later is usually easy and is not accompanied by any more bleeding. When no satisfactory control is possible the decision has to be made to abandon the operation and plug the wound with gauze. Two to three days later the gauze can be taken out under anaesthesia, preferably in the theatre in case further loss occurs.

(2) Deliberate control

There are many methods of deliberate control, but only those in practical use will be mentioned.

Ligatures

Ligatures are most commonly used. As a preliminary the vessel, and whenever possible the vessel alone, is clamped by means of a Spencer Wells artery

the free blood or blood clot may be a problem. When the bleeding is into a cavity or tube with an outlet to the exterior, the matter resolves itself. In other cases, surgical intervention is necessary to obviate sepsis or pressure effects.

(4) Treatment of reactionary haemorrhage

The treatment of severe reactionary haemorrhage is to expose the bleeding point and to ligate it as soon as possible. Slight loss is controlled by rest, morphine, pressure and occasionally when superficial by a stitch. Intermediate degrees require judgement as to when to interfere, but in general terms, if the bleeding continues and the patient reacts unfavourably direct ligation is called for.

(5) Treatment of secondary haemorrhage

In septic wounds the likelihood of secondary haemorrhage must not be overlooked. In modern surgery, with the more enlightened treatment of wounds and the use of chemotherapy, it should be, and is, less common. The onset of such bleeding calls for prompt and efficient treatment. In the ward, a tourniquet should be applied immediately where practicable, or the wound should be plugged and a blood transfusion then begun if required. Under good conditions in a theatre the wound should then be explored thoroughly, and the bleeding vessel securely tied with catgut. The septic condition of the tissues may make this difficult, and other methods such as ligation by suture, cautery or plugging may have to be resorted to. The proximal ligation of the main vessel is tempting but in practice is unsatisfactory. It should only be done on rare occasions, and when a more direct approach to the bleeding artery has already been attempted. Occasionally, amputation or re-amputation is necessary.

(6) Treatment of effects of haemorrhage

The aim in general treatment is to keep the vital centres functioning, restore the volume of circulating fluid, and later, to assist the body in replacing the blood by natural processes.

The patient is rested in bed with the head lower than the feet and given an adequate dose of morphine. If an anoxaemia is apparent, oxygen is inhaled through a B.L.B. mask at the rate of 6–7 litres a minute.

Once the haemorrhage has been stopped it is safe to increase the blood volume and raise the blood-pressure without fear of further bleeding. Slight or moderate loss can be restored by the patient drinking plenty of fluids in the form of water, saline or tea. When the blood-pressure falls to 80 millimetres of mercury or less, the use of whole blood is indicated as being the most physiological fluid, provided it is of the correct group and is cross-matched against the patient's serum as an additional safeguard. It can be run in rapidly (1 pint in 7–10 minutes) until the blood-pressure rises above 100 millimetres of mercury, when the rate should be slowed down to 1 drop a second, in order to prevent overtaxing the heart. In severe haemorrhage, the quantity required to restore the blood volume to something approaching normal may be several pints. Although the use intravenously of crystalloid solutions such as normal saline has been discredited, because they remain only temporarily in the circulation, they may be used in circumstances where blood is unobtainable or where there is delay in procuring it.

remains untreated the more oedema and disuse play their part in congealing the tissues, and the slower the healing process becomes.

Diseases reflected in the hand

It should always be remembered that the hand may express the sentiments of disorder elsewhere. Thus rheumatism, gout, chronic pulmonary disease and central nervous manifestations may here be first apparent. The scalenus anticus syndrome, luxation of cervical intervertebral discs, and brachial plexus disturbances may here commence their clinical course.

(2) Functions of the hand

The hand is a beautiful example of adaptation of form to function. Close study of the correlating movements employed in prehension show that there



FIG. 197.—Digital grasp.



FIG. 198.—Palmar grasp.



FIG. 199.—The position of function. The basic position of rest and splintage.

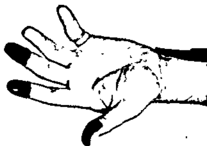


FIG. 200.—Surfaces of maximal sensibility.

Grasp

are two primary grasping actions, first digital, where the thumb is opposed to one or more digits (Fig. 197), and secondly palmar, where the digits are flexed to the palm (Fig. 198).

Acting with the prime movers many synergistic and antagonistic functions take place, a nice balance of which is essential for dexterity (Fig. 199).

Sensation

Sensation is as important as movement. The areas most highly developed in tactile sensation are the pulps of the thumb, index and middle fingers (Fig. 200).

Treatment of hand injuries should be based upon a thorough appreciation of the normal physiology.

(3) Operative technique

Pre-operat[ive] preparatio[n]

Preparation with Cetavlon (cetyltrimethylammonium bromide), or thorough cleansing with soap and water followed by alcohol, is simple and effective. Nails should be cut short and given special attention with the brush and nail

HAND

By J. N. BARRON, F.R.C.S.Ed.
Senior Surgeon, Plastic and Jaw Unit, Park Prewett Hospital, Basingstoke

1. GENERAL CONSIDERATIONS

(1) Pathology

Scar formation 178.] Cicatrix is the cancer of the hand. It impairs nutrition and destroys vitality and function.

The causes of cicatrix are infection, oedema, disuse and granulating surfaces, all of which can be controlled. When scar tissue permeates the hand, smooth gliding surfaces are lost, delicate balance of intrinsic muscles is deranged, tiny capsular ligaments shorten, and vascular and lymphatic systems are strangled. A vicious circle is readily established, the prevention of which is infinitely easier than the cure. The longer an infection or raw surface

Many composite cases present themselves and these may be exceedingly complex. In general, operative treatment should be commenced early (in the second or third year), particularly in cases in which subsequent development

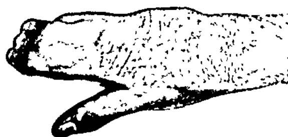


Fig. 203 (*a*).—Complex syndactyly shown photographically.



Fig. 203 (*b*).—Complex syndactyly shown radiographically.

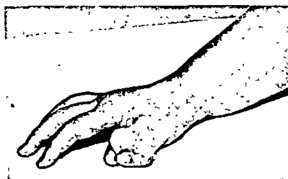


Fig. 204.—Polydactyly. Accessory phalanx of the thumb.

will aggravate the deformity, and in some cases a long surgical programme is necessary to obtain the optimal result.

Of these groups syndactyly will be described, as the others are essentially individual problems.

Theatre routine

Tourniquet

file. Nail folds are painted with collodion or Mastisol. In the theatre the hand and forearm are encased in stockinet which is incised to allow access for the skin incisions. (Fig. 201.) A pneumatic tourniquet can be used with safety for

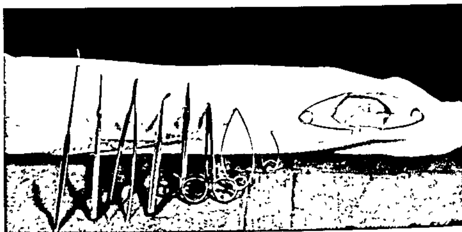


Fig. 201.—Hand and arm enclosed in stockinet. Access to operation area and the delicate instruments used in hand surgery are shown.

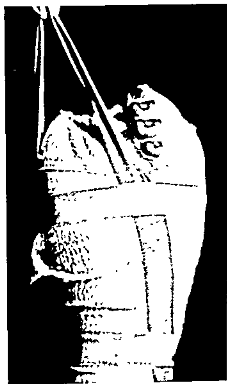


Fig. 202.—A pressure dressing of wool and crêpe bandage is held by strapping which provides a loop for elevation of the limb.

up to 1½ hours and may be reapplied for the same period if released for a 10-minute interval. Whatever procedure is carried out, a strict atraumatic technique should be used. The finest forceps and hooks are used for manipulation and have the minimal crushing effect upon the tissues. (Fig. 201.) Crushed tissue provokes oedema and cicatricial reaction. Haemostasis should be absolute.

Every operation should have as its epilogue a pressure dressing of wool and elastic bandage, applied so that all skin surfaces are equally compressed. Oedema and haematoma are thus prevented and the circulation is supported. The hand should be elevated for 48 hours to assist drainage from the limb. (Fig. 202.)

2. CONGENITAL DEFORMITIES

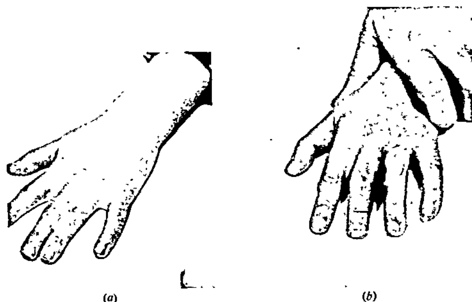
Many bizarre types of anomalous development are to be found in the hand. These deformities fall into 5 main groups: (1) fusing of contiguous digits, syndactyly (Fig. 203); (2) excessive number of digits, polydactyly (Fig. 204); (3) absence of central digital rays, cleft hand; (4) mal-alignment of fingers or clinodactyly; and (5) congenital amputation or adactyly (Fig. 205).

Classification

complexes may be set up by the unmerciful ribaldry of school life. In other cases in which, owing to unequal phalangeal development or to synostosis, secondary deformities are bound to occur, operation should be undertaken early, usually during the second year.

Operation

The oft-quoted procedure using the skin of the web to repair the defects on the sides of the fingers is an unqualified failure. The tension required for closure is too great, and necrosis is the inevitable result. The technique employed is vertical splitting of the web, and the creation of dorsal and



(*a*) (*b*)

FIG. 207—(*a*). Syndactyly (Web type). (*b*) After repair by lateral skin grafts and interdigitating base flaps.

volar flaps based proximally at the level of the metacarpo-phalangeal joints (Fig. 206 (a)). These flaps are interdigitated to form the new web based in its correct position, and the lateral digital skin defects are made good by thick split-skin grafts. These grafts are cut from the upper arm and are applied to the raw areas on a previously-moulded wax impression. Stent or Kerr's dental compounds are ideal for this purpose (Fig. 206 (b)).

The mould is left in position for 2 weeks and the after-care should be directed towards the stabilization of new skin and the prevention of contractures in the junction lines by exercise therapy (Fig. 207 (a) and (b)).

3. DUPUYTREN'S CONTRACTURE

(1) Definition

Dupuytren's contracture is a fibromatous process which, originating in the palmar fascia, extends to involve the surrounding connective tissues of the skin. The effect is to induce the fingers into flexion and to impair the nutrition and function of the part. The finger most frequently affected is the ring finger, and after this the little, middle and index fingers and thumb in that

Syndactyly

The fusing of digital rays is the commonest congenital deformity of the hand. It is most frequently seen in male children, may be symmetrical and associated with a similar condition in the feet. The degree varies from simple enlargement of the normal web between the fingers to complete fusion of contiguous digits, including transphalangeal synostosis. In some cases of complete fusion there is found a single nerve and tendon common to the two rays, and these require complicated intraneural dissections and tendon grafts in their treatment. Simple skin webs which during the early growth period will not produce secondary deformities should be repaired at the age of 5 or 6 years. After this time,

FIG. 205.—Adactyly. Failure of digital development.

When to operate

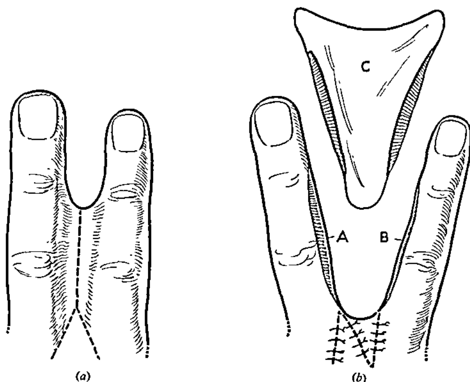


FIG. 206.—(*a*) Incision for web syndactyly. The web is completely divided to the mid-point of the proximal phalanx where on both volar and dorsal aspects diverging incisions create two triangular base flaps. (*b*) Syndactyly. The flaps are interdigitated and the lateral raw areas on the fingers are covered with thick split-skin grafts. These are applied on a wax mould C which is fitted between the fingers and held with a firm pressure dressing

removed on the tenth day and exercises commence on the fourteenth day. Maximal finger extension should be regained in from 1 to 3 months, but it is unwise to force this either at operation or in the immediate post-operative phase.

4. INJURIES

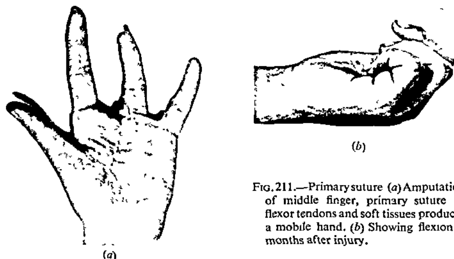
(1) Skin

Preservation of function in the hand depends so intimately upon an intact skin cover that in the treatment of recent injuries this should be the primary



(*a*) (*b*)

FIG. 210.—(*a*) Gross laceration from a premature explosion. Volar aspect. (*b*) Dorsal aspect.



(*a*) (*b*)

FIG. 211.—Primary suture (*a*) Amputation of middle finger, primary suture of flexor tendons and soft tissues produces a mobile hand. (*b*) Showing flexion 4 months after injury.

consideration. Successful closure of wounds depends upon thorough surgical toilet and upon the absence of tension across the suture lines. Two causal

order (Figs. 208 and 209). Most authorities are agreed that trauma is not the causal factor and this has a bearing on compensation claims.

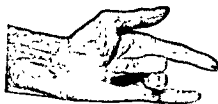


FIG. 208.—Dupuytren's contracture. Third and fourth finger involved.



FIG. 209.—Dupuytren's contracture. Fifth finger involved.

(2) Treatment

Radical surgery is undoubtedly the method of choice, and complete ablation of the palmar fascia is advisable. In early cases this is done in one stage. When there is considerable contracture at the digital joints a preliminary subcutaneous fascial tenotomy should be carried out 10–14 days before fascial excision, so that splintage and exercises may replace the bow-strung digital nerves and vessels, and tone up the circulation in the skin.

Old and neglected contractures may require complete palmar skin replacement, and for these cases an abdominal tubed pedicle is prepared 1 month before the hand dissection. Occasionally there is indication for amputation of a digit.

(3) Technique of fascial excision

The approach to the palmar fascia is made through two incisions after the application of a tourniquet. The first incision lies in the thenar crease and extends proximally to the level of the volar carpal ligament. Through this incision the skin of the palm is undermined as far as possible, taking with it the subcutaneous tissue but leaving behind any abnormal fibres which are extensions from the contracted fascia. The palmaris tendon is then divided just distal to the volar carpal ligament and, working distalwards, all the fascia which can be reached is dissected out.

The second incision is made in the distal palmar crease from the index to the little finger. By the same process the remainder of the fascia is removed as far as the bases of the fingers including all the deep septa which attach to the shafts of the metacarpals. Through mid-axial incisions in the affected fingers the digital fascial extensions are excised, care being taken here and in the distal palm to preserve the nerves which are often closely involved in the scar mesh.

The tourniquet is released and absolute haemostasis secured. The incisions are sutured. Any skin which is avascular should be treated as a Wolfe graft, or in advanced cases the previously prepared tubed pedicle is sewn into the palm.

Post-operative care

Careful pressure dressing, plaster immobilization and elevation are essential to prevent haematoma and to ensure healing *per primam*. The stitches are

In deep wounds a minimum of foreign material should be included, and the finest catgut 6/0 is used for persistent bleeders, and to draw together aponeurotic layers. Penicillin control is a safety factor which should not be omitted. It is possible in gross, recent wounds with much skin loss to repair them immediately by abdominal skin flaps. Thus in cases in which later tendon and bone grafting procedures will be necessary, satisfactory conditions for this can be assured.

(2) Tendons

Severed tendons are a surgical emergency, requiring skilled attention and good conditions for treatment. The best functional results are obtained from primary suture, and this should be done within 6 or 8 hours of injury. Suture should be combined with meticulous wound toilet and the technique described by Bunnell (1944) offers the best chance of success. The cause of injury has an important bearing on the prognosis. Wounds inflicted with a clean, sharp instrument can be expected to do well, but those in which there is a "crush" element present are frequently complicated by cicatrix.

Flexor tendons

For all tendon repairs No. 35 gauge stainless steel wire is the suture material of choice, as the tissue reaction to it is minimal. For flexor tendons the suture is arranged in such a fashion that it can be removed in 3 weeks when union is sound.

Technique of suture

A wire suture, loaded at each end with a fine straight needle, is passed crisscross through the proximal tendon and brought out through the cut surface

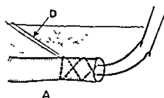


FIG. 213.—Showing the wire loaded to a needle at each end, and the trip wire looping through the proximal suture.

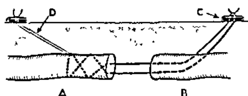


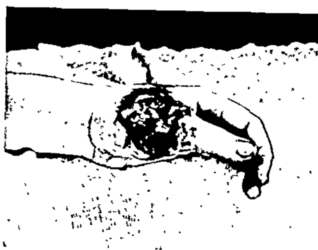
FIG. 214.—The method of stainless-steel wire tendon suture. The wire is introduced crisscross into A the proximal tendon, and threaded through the distal end B to penetrate the skin and to be twisted over a small button C. The trip wire D for removal is passed proximally to emerge through the skin and is loosely twisted over a second button.

(Fig. 213). Both ends of the wire are threaded longitudinally through the distal tendon and emerge 2 centimetres distally where they are made to traverse the subcutaneous tissue and skin.

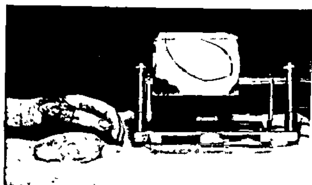
Before drawing tight, a trip wire is threaded through the first loop of suture wire in the proximal tendon, twisted and carried back to emerge through the skin, where it is tied over a small button (Fig. 214). The main suture is then drawn tight and the tendon ends are approximated. This suture is also tied over a button and the wound is closed. A light plaster which allows movement in all other digits is applied. Over all a massive pressure dressing is

Post-operati[ve] treatment

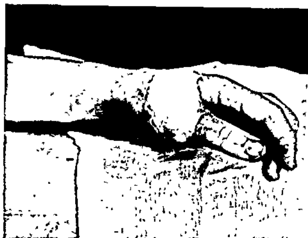
elements in every *injury should* be considered—the "crush" and the "cut". Most injuries are caused by a combination of the two, and the reaction of the tissues differs critically depending upon which predominates. The greater the "crush" element the more widespread will be the thrombosis and capillary damage with secondary necrosis, oedema and risk of infection. When operation is being considered this factor is just as important as the time since injury (Fig. 210 (a) and (b)).



(*a*)



(*b*)



(*c*)

Fig. 212.—(*a*) Skin loss to be treated by a free graft. (*b*) The Padgett dermatome is used to cut the skin, from which an accurate pattern of the defect is taken. (*c*) The graft sewn into position.

Whenever feasible wound closure should be aimed at, and its success will depend upon the efficient toilet of the presenting surface. This is best accomplished under a continuous slow-flowing stream of saline in which the frayed tissues float up and are easily identified. All layers should be trimmed systematically of non-viable and potentially non-viable tissues, and this is possible only with the aid of a tourniquet and adequate anaesthesia. In wounds in which there has been a large degree of "crush" element the importance of wound toilet is greatly enhanced (Fig. 211 (a) and (b)).

Skin tension should be carefully ascertained before suture, and if abnormal a plastic procedure or skin graft should be used rather than tension sutures (Fig. 212 (a), (b) and (c)).

In deep wounds a minimum of foreign material should be included, and the finest catgut 6/0 is used for persistent bleeders, and to draw together aponeurotic layers. Penicillin control is a safety factor which should not be omitted. It is possible in gross, recent wounds with much skin loss to repair them immediately by abdominal skin flaps. Thus in cases in which later tendon and bone grafting procedures will be necessary, satisfactory conditions for this can be assured.

(2) Tendons

Severed tendons are a surgical emergency, requiring skilled attention and good conditions for treatment. The best functional results are obtained from primary suture, and this should be done within 6 or 8 hours of injury. Suture should be combined with meticulous wound toilet and the technique described by Bunnell (1944) offers the best chance of success. The cause of injury has an important bearing on the prognosis. Wounds inflicted with a clean, sharp instrument can be expected to do well, but those in which there is a "crush" element present are frequently complicated by cicatrix.

Flexor tendons

For all tendon repairs No. 35 gauge stainless steel wire is the suture material of choice, as the tissue reaction to it is minimal. For flexor tendons the suture is arranged in such a fashion that it can be removed in 3 weeks when union is sound.

Technique of suture

A wire suture, loaded at each end with a fine straight needle, is passed criss-cross through the proximal tendon and brought out through the cut surface

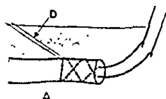


FIG. 213.—Showing the wire loaded to a needle at each end, and the trip wire looping through the proximal suture.

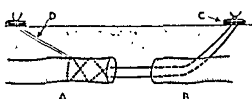


FIG. 214.—The method of stainless-steel wire tendon suture. The wire is introduced criss-cross into A the proximal tendon, and threaded through the distal end B to penetrate the skin and to be twisted over a small button C. The trip wire D for removal is passed proximally to emerge through the skin and is loosely twisted over a second button.

(Fig. 213). Both ends of the wire are threaded longitudinally through the distal tendon and emerge 2 centimetres distally where they are made to traverse the subcutaneous tissue and skin.

Before drawing tight, a trip wire is threaded through the first loop of suture wire in the proximal tendon, twisted and carried back to emerge through the skin, where it is tied over a small button (Fig. 214). The main suture is then drawn tight and the tendon ends are approximated. This suture is also tied over a button and the wound is closed. A light plaster which allows movement in all other digits is applied. Over all a massive pressure dressing is

Post-operative treatment

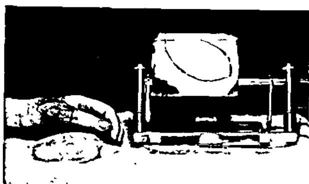
elements in every injury should be considered—*the "crush" and the "cut"*. Most injuries are caused by a combination of the two, and the reaction of the tissues differs critically depending upon which predominates. The greater the "crush" element the more widespread will be the thrombosis and capillary damage with secondary necrosis, oedema and risk of infection. When *operation is being considered* this factor is just as important as the time since injury (Fig. 210 (a) and (b)).

Whenever feasible wound closure should be aimed at, and its success will depend upon the efficient toilet of the presenting surface. This is best *accomplished* under a continuous slow-flowing stream of saline in which *the frayed tissues float up* and are easily identified. All layers should be trimmed systematically of non-viable and potentially non-viable tissues, and this is possible only with the aid of a tourniquet and adequate anaesthesia. In wounds in which there has been a large degree of "crush" element the importance of wound toilet is greatly enhanced (Fig. 211 (a) and (b)).

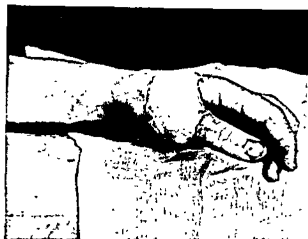
Skin tension should be carefully ascertained before suture, and if abnormal a plastic procedure or skin graft should be used rather than tension sutures (Fig. 212 (a), (b) and (c)).



(*a*)



(*b*)



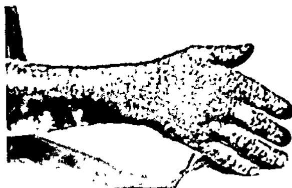
(*c*)

Fig. 212.—(*a*) *Skin loss to be treated by a free graft.* (*b*) The Padgett dermatome is used to cut the skin, from which an accurate pattern of the defect is taken. (*c*) The graft sewn into position.

superficial blisters are clipped. The hand is dusted with penicillin-sulphathiazole powder and all surfaces are covered with Vaseline gauze strips. The position of function is then obtained, and wool wrung out in normal saline is packed in against all surfaces until the hand is encased in a spherical mass with only the finger tips extruding.

A crêpe bandage is firmly and evenly applied up to the mid-forearm, and over all is placed a light plaster cast with a loop attached for elevation. (Fig. 216.)

Elevation is maintained for 4 days, during which time the patient is taught "static contractions" of all hand and forearm muscle groups. These he should do for 5 minutes every ½ hour. On the fourth day, by which time oedema should be controlled, the dressing is inspected and an accurate diagnosis made. If it is obvious that there are no areas of total skin destruction a lighter dressing is applied, a moulded plaster slab is fitted to check wrist flexion, and active movements are commenced. Elevation is maintained or discarded according to the condition of the circulation and the presence or absence of oedema.



(a)



(b)

FIG. 215.—(a) Partial-thickness skin loss burn. (b) Volar aspect. Note oedema and blistering.

On the eighth day the dressing is again inspected and reduced. If there is good tone in the forearm extensors the plaster is discarded, and the minimum of dressing compatible with protection is used. At this stage it may be convenient to use a Vaseline gauze bandage to cover the fingers and palm, and to tie the hand into a sterile linen bag in which movements may freely be practised.

Physiotherapy

The assistance of a physiotherapist should be sought from the beginning, his role being the maintenance of muscle tone and the re-establishment of normal movements and circulation. When the skin has become stabilized, the high temperature paraffin wax bath is the most valuable stimulus to function, and with correct exercise therapy disability should be minimal.

Full-thickness skin loss

When higher temperature or longer exposure has destroyed all the skin layers important alterations in treatment are necessary to cope with the

used to control oedema and this is discarded on the fourth day. The plaster and suture remain for 3 weeks, during which time static contractions of the affected muscle belly are practised and active movements of all other fingers are allowed.

The suture is removed by pulling on the trip wire after cutting the suture wire free from its button.

When both flexors to a digit are severed the profundus alone should be sutured, and the sublimis removed back to the palm. If suture has to be done in the proximal finger segment the tendon sheath should be slit open laterally, to allow for swelling. When there is "crush" element present in connexion with a severed flexor in a finger, rather than place the suture line in an area which will react with oedema and cicatrix, it is better to sacrifice the profundus tendon back into the palm, and put in a full-length graft to its normal insertion in the distal phalanx. The results of these grafts are superior to simple suture unless there is complete absence of "crush" effect.

Extensor tendons

Extensor tendons are repaired by simple interrupted wire sutures which are left permanently *in situ*, unless the suture line is over a joint, when they are made removable. Extensor tendon grafts do well, and there need be no hesitation in their use. The secret of all tendon repairs is the adoption of an absolutely atraumatic technique.

(3) Nerves

Loss of sensation is as disabling as loss of movement, and for this reason severed nerves should receive every consideration in the injured hand. It is perfectly feasible to suture even the fine digital nerves and, if anaesthesia and trophic changes are to be avoided, nerve suture should form part of the repertoire of the surgeon faced with hand injuries.

Primary nerve suture is permissible in a fresh, clean wound and good results can be expected. If, however, there is any doubt about the possibility of obtaining primary wound union, a silk stitch should be put in to hold the divided nerve ends together, and secondary suture should be undertaken at a later date. For nerve suture the finest silk should be employed to coapt the cut ends of the sheath, careful orientation of the nerve bundles is necessary, and the suture line should be placed in a scar-free bed.

(4) Burns

Thermal, electrical and chemical trauma can produce devastating effects upon the hand. For the purpose of treatment they are considered as either partial-thickness or total-thickness skin loss. The exact diagnosis is often not apparent until the fourth or fifth day after injury, and this is because subsequent tissue loss due to infection and thrombosis may transform a partial-thickness into a full-thickness skin destruction. (Fig. 215 (a) and (b).)

(a) *Heat burns*

Partial-thickness skin loss

The primary objects of treatment are prevention of infection, oedema and thrombosis, and the conservation of function. Under aseptic conditions the skin is gently cleansed with a detergent such as Cetavlon or Phemeride, and

(5) Finger amputations

A conservative attitude should be adopted when amputations of the fingers are considered, and the removal of a thumb requires so much justification that it should be a rarity in surgical practice. *Indications*

Although much can be done by reconstructing tendons, nerves and joints, it is time-consuming and the economic factor is to be considered. If a long period in hospital and months of absence from work will not pay an ultimate dividend in function and in earning power it is better to amputate. This applies particularly to the fifth finger.

In general, the indications for digital amputation apart from chronic infections and neoplasms are complex injuries; gross skin loss with lacerated flexor tendons; compound interphalangeal joints with flexor tendon laceration; skin loss with comminuted fractures into joints—all these are strong arguments for immediate removal. It is seldom that amputation is necessary for a single lesion such as cut tendon, skin loss or fracture.

When indications for amputation are present both functional and cosmetic results should be considered. The long digital stump is the most useful, provided there is full joint mobility and a scar-free tip. Disarticulations are satisfactory if the cartilage is removed and the phalanx trimmed a little to reduce its width.

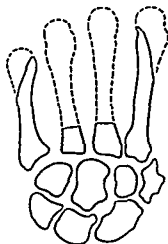


Fig. 218.—Diagram of metacarpal amputations for best cosmetic results.

The standard skin flaps are seldom used as most amputations are carried out by a "filleting" process and excess of skin is fashioned to fit the contour of the bone end. Suture lines should be dorsal so far as is possible, and the volar skin arranged to lie accurately, without either redundancy or tension. The whole function of the stump may be jeopardized by careless skin arrangement and suture.

Disarticulation through the metacarpo-phalangeal joints gives good functional, but poor cosmetic, results. For the manual worker who is not sensitive about his deformity it is entirely satisfactory. When appearance is paramount or when consciousness of disfigurement will interfere with the use of the hand, oblique section of the shafts of the second and fifth metacarpals, or transverse section of the third and fourth metacarpals, near the base, is the method of choice. (Fig. 218.) The palm is thus narrowed but remains stable, and the loss of the digit is not obvious.

5. INFECTIONS

A radical change is taking place in the treatment of hand infections. With the introduction of penicillin new vistas of conservative treatment are opened up, and experience may confirm the hope that many of the catastrophies resulting from previous methods will be averted.

The importance of accurate early diagnosis remains undiminished, and the first principles of the surgery of infection stand.

different pathological processes. With full-thickness skin loss not only must the whole area be thrown off as a slough, but spontaneous regeneration can occur only from the edges of the defect after the period of infection and necrosis is past. (Fig. 217.) If healing is allowed to take its natural course—as may be permissible in other body areas—the secondary effects of the oedema infection and cicatrix will so diminish function in the delicate gliding pulley and capsular mechanisms of the hand that permanent disability will be the inevitable sequel.

It is then the surgeon's duty to reduce the time between hurt and healing to the minimum. The following routine will be found effective.



FIG. 216.—Plaster-of-Paris elevation splint.

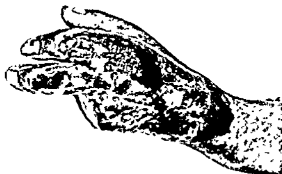


FIG. 217.—Full-thickness skin loss burn. Auto-amputation of fingers and exposed metacarpals.

For the first 4 days treatment should be as described for partial-thickness skin loss burns, with pressure dressing, elevation and static muscle contractions. After this, daily saline arm baths are given, and surface trimming is done each 24 hours with forceps and scissors to clear away as much necrotic tissue as possible. Careful bacteriological control is required, and between dressings elevation and exercises are continued. With this technique, granulations appear early and infection is kept at a minimum. The moment the hand is slough-free the raw surface should be covered with a split-skin graft and immobilized for 7 days, after which reduced dressings and increased exercises will stimulate circulation and promote function.

(*b*) *Electrical and chemical burns*

Burns caused by these agencies present ideal conditions for primary excision and skin grafting. Particularly with electrical burns in which the necrotic tissue is so slowly thrown off an *excision d'urgence* and skin graft will give a functional result unobtainable by any other method. In these burns the line of demarcation is easily found and excision into healthy tissue is possible. The problem always arises as to whether tendons are viable, but on the whole it is advisable to leave them and cover them with the graft.

Primary Wolfe-graft repairs of electrical burns on the volar surfaces of the fingers produce admirable results, and deep palmar burns can be treated by immediate skin flaps from the thigh, abdomen or opposite forearm. Much scarring and disability are spared by these methods.

An acutely tender fusiform swollen finger, held in flexion and resisting extension, with maximal tenderness at the base, has as its pathology an acute tenosynovitis and should be treated immediately. Surgical treatment consists of a single lateral mid-axial incision from the level of the distal interphalangeal joint to the base of the finger, and a separate transverse incision in the distal *Clinical picture* *Treatment*

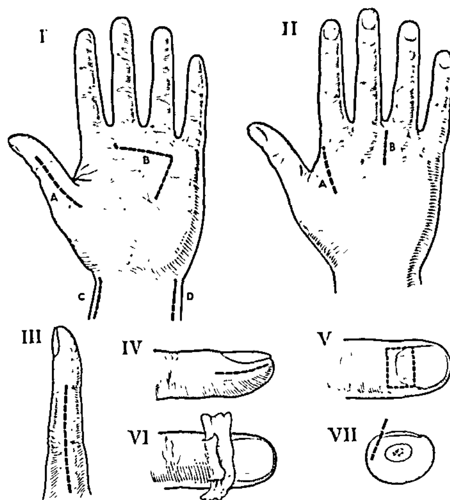


Fig. 219.—Incisions for drainage of hand infections. IA. Flexor pollicis longus sheath. IB. Ulnar bursa and palmar space. IC. Proximal extension of radial bursa. ID. Proximal extension of ulnar bursa. IIA. Thenar space. IIB. Collar-stud web abscess. III. Digital flexor tendon sheath. Note line of incision is dorsal to the flexion creases. IV. Felon or whitlow. V. Paronychia, showing area of nail to be removed. VI. Tamponage holding proximal fold back for drainage. VII. Line of incision for lateral nail-fold infections.

palm, to drain the proximal end of the sheath. The sheath itself is opened laterally throughout the length of the finger, and again in the palm. (Fig. 219, III.) The skin edges are packed open with penicillin cream gauze, and subsequent treatment carried out as described for pulp abscess. On no account should through-and-through drainage be established, and a volar longitudinal incision is a surgical crime. Tamponage should be carefully placed

(1) Felon or whitlow

This is an infection of the pulp space from direct trauma. Pus under high tension soon develops in this rigid enclosure and the blood supply is embarrassed, causing necrosis of soft tissue and of the terminal phalanx. Extension to the joint or to the flexor tendon sheath may occur, and pus may travel up to the palm, or lymphatic spread endanger limb and life. Systemic penicillin should be given from the outset. Early incision and drainage are essential for the release of tension and the maintenance of the circulation.

Treatment

Under general anaesthesia an incision commencing ¼ inch distal to the flexion crease is carried forward just short of the tip. (Fig. 219, IV.) A similar contralateral incision is made and the bistoury is passed completely through the pulp widely opening up all the septa. A penicillin cream wick is passed through and the hand is immobilized in a plaster slab holding the finger in flexion. The wick is changed after 48 hours and on the fourth day is discarded for a surface dressing introduced slightly between the wound edges to keep them open. This dressing is changed every 2 or 3 days until healing is complete. The plaster is dispensed with when the signs of acute inflammation have subsided and every precaution should be taken to prevent secondary infection. Heat should play no part in this or any other acute digital infection, as the resulting congestion and oedema does nothing except embarrass the already overburdened circulation and results in stagnation, impaired drainage and raised interstitial tension.

Post-operative treatment

Rapid healing will leave a serviceable pulp with little scar. Occasionally, late scar excision and rearrangement are necessary to correct irregularities in pulp contour.

(2) Paronychia

This infection, frequently resulting from clumsy manicure, commences in the nail fold and travels round the three attached sides of the nail. Pus may track under the nail or creep into the pulp space, and so proximally up the flexor tendon sheath.

Tension here is not the predominant factor and mild cases subside with splintage and systemic penicillin. Should pus form, however, as evidenced by a change in the type of pain—increased local tenderness and swelling—the following operation should be done.

Treatment

The proximal third of the nail is removed from the nail bed and the cavity thus formed packed with penicillin cream gauze. (Fig. 219, V and VI.) If the lateral extensions of the infection require it, the nail folds should be opened widely and packed as well. (Fig. 219, VII.)

Post-operative treatment is as for pulp abscess.

(3) Teno-synovitis

Infection in a flexor sheath occurs from direct puncture, usually at the creases or from extension from a pulp abscess. The course is rapid, there being no barrier to direct spread. The process continues up to the palm and, in the case of the thumb and little finger, may have direct access to the radial or ulnar bursa. From the second, third and fourth fingers spread may occur to the thenar or palmar space, and thence to contiguous digits or to the bursae.

(7) Palmar space infection

The palmar space is involved from sheath infection of the third, fourth and fifth fingers, or from direct extension from these fingers via the lumbrical canals. The symptoms are similar to those found in ulnar bursa infection, but the wrist does not tend to flex so much and pressure in the lower forearm does not increase pain. The palmar space is opened by an incision similar to that *Treatment* used for the ulnar bursa approach. (Fig. 219, IB and IIB.)

(8) Thenar space infection

This space is involved by extension from thumb and index finger infections, from direct trauma, or from the palmar space. The swelling points in the first web, and the diagnosis is obvious. Incision is best made on the dorsum, longi- *Treatment* tudinally, and towards the ulnar side of the web. (Fig. 219, IIA.)

(9) Tuberculous teno-synovitis

This is a chronic progressive invasion of the synovial tissues by the tubercle *Pathology* bacillus. For a long time the pathology is confined to the synovia, but later, tendons and connective tissues are invaded and a crippled sclerotic hand, fenestrated with sinuses, is the final picture.

Volar tendon sheaths are twice as commonly involved as are dorsal sheaths. The early symptoms are swelling, loss of dexterity, weakness and tenderness. Fluid and crepitus elicited in a chronic swelling in the region of the synovial sheath warrant a diagnosis of tuberculous teno-synovitis. A thorough search *Treatment* for tuberculosis elsewhere should be made. Except in rapidly advancing cases, in which resistance is low, surgical treatment is the method of choice. In the few "acute" types, plaster immobilization and a general tuberculosis regimen should be instituted, and operation undertaken when a sclerotic barrier has been put up.

The surgery consists of complete excision of all infected synovial tissue. This is done through a well-planned incision, and meticulous care is taken to remove every vestige of disease. Fibrotic infiltration and oedematous, granulomatous fungations embedding melon-seed bodies are found at the centre of the diseased area, and swollen injected tissues at the periphery. Tendons need not be sacrificed unless ragged and scarred, and surprisingly good function can be expected. Post-operative follow-up is necessary to check recurrence.

When tendons have been removed subsequent grafting operations can be planned if necessary a year or more afterwards, if the relevant joints have preserved their function.

6. RECONSTRUCTIVE SURGERY

(1) Skin

When skin alone has been lost either in the recent injury or in the wound healed by a secondary epithelialization, replacement by a free skin graft will suffice. On extensor surfaces, a split-skin graft cut freehand or with a Padgett dermatome is used, but on volar surfaces, where the full buffering action of the dermis is required to support the epithelium against constant trauma and pressure, a full-thickness or Wolfe graft is desirable. The function of the sub- *Subcutaneous tissue* cutaneous tissue in the hand is, however, so important that when it, too, is destroyed by avulsion, heat or infection it should be replaced. Many methods

to prop the wound open, but the material should not make contact with the tendons.

Recent work has shown, however, that better results can be obtained by local injection of penicillin into the sheath without incision, and this treatment, if commenced early, results in a high percentage of cures with a 100 per cent function (Grossmark and Plewes, 1945).

The proximal cul-de-sac of the sheath is punctured and aspirated, and 500 units of penicillin in ½ cubic centimetre of solution are injected. This is repeated in 48 hours, the hand, meanwhile, being splinted in the position of function. Occasionally a third injection is necessary, but this is uncommon. The subsidence of infection is dramatic; pain and tenderness disappear within a few hours, and natural drainage is established.

(4) Ulnar bursitis

Ulnar bursa

Ulnar bursa infections are evidenced by acute tenderness and swelling on the ulnar side of the palm; the third, fourth and fifth fingers are held in flexion, and resist extension. The wrist assumes a position of flexion, and pressure above the wrist causes pain in the palm and fingers. The dorsum of the hand is oedematous. It is usually infected by extension from a tendon sheath involvement of the fifth finger, and infection spreads from the bursa under the volar carpal ligament into the fascial spaces in the forearm.

(5) Radial bursitis

The radial bursa is usually infected from the flexor longus pollicis sheath. Here the swelling and tenderness are confined to the radial side of the palm, and the thumb and index finger point to the lesion by their flexion and resistance to extension.

(6) Treatment of bursitis

The ulnar bursa is approached by a curved palmar incision commencing at the base of the middle finger in the distal palmar crease, and sweeping proximally up the radial side of the hypothenar eminence. (Fig. 219, IB.) When the palmar aponeurosis is divided the swollen sheath bulges into the incision and should be widely opened. In cases in which pus has travelled to the forearm the proximal portion of the sheath should be drained through an incision on the ulnar side, above the wrist between the flexor carpi ulnaris tendon and the ulnar nerve anteriorly, and the lower end of the ulna posteriorly. (Fig. 219, ID.) The bursa immediately presents and is drained.

Post-operative treatment is as described for the other infections, but is inevitably more prolonged, and wound tamponage is required for longer periods. The digital sheath of the thumb is opened by a mid-axial incision on the radial side, and the proximal extension of the bursa by an incision on the radial aspect of the forearm, above the wrist between the flexor carpi radialis and the radial vessels. (Fig. 219, IA and C.)

Radial bursa

In general, incisions must be generous and provide free drainage to all parts of infected bursae. The results of treatment depend upon this, and upon the promptitude with which it is done. It is likely that the penicillin injection technique will prove satisfactory in bursal infections, but this must be combined with treatment for the primary cause. A bursitis is nearly always secondary to digital infection, and this should not be overlooked.

Although sensation returns after several months in the transplanted skin it never recaptures the fine discriminatory sensibility of the normal hand; thus



(a)



(b)



(c)

FIG. 221.—(a) Old burn contracture of palm showing maximum possible extension. (b) Abdominal tubed pedicle transferred via the wrist. (c) Pedicle inset allowing freedom of movement and improved circulation.

where possible volar skin losses should be replaced with hand skin, and this applies particularly to the volar surfaces of the thumb, index and middle fingers. (Fig. 222 (a), (b), (c) and (d).)

(2) Thumb replacement

The hand without a thumb has lost opposition, one of its most important functions. Three methods are available to overcome this disability: the artificial thumb, the pedicle and bone graft thumb, and pollicization. *Artificial thumb*

An artificial apposition post can be supplied in the form of a glove into which is built a rigid thumb, the base of which is fixed firmly to the wrist to prevent instability. The disadvantages are obvious, and it is seldom the method of choice.

By importing a suitably-shaped piece of abdominal skin into which is subsequently placed a bone pack fixed to the metacarpal stump, or to the trapezium, a thumb-like digit can be obtained. (Fig. 223 (a), (b) and (c).) *Technique and bone graft method*

If the metacarpo-trapezium joint is intact, the transference of flexor and extensor tendons to insertions in the bone graft will provide movement.

This method has two drawbacks: lack of normal tactile sensation and a tendency to poor vascularity established in cold weather. It is, however, the method used when there is only one digit standing in the hand, or when the patient does not agree to the transplantation of a finger. This multiple stage repair is very time-consuming.

are available for the repair of skin and subcutaneous tissue defects. All depend for their success upon the principles of "transference in vascular continuity" and are designed either as "direct" or "pedicle" flaps. (Fig. 220(a), (b) and (c).) Donor sites for these flaps are the abdomen, chest, thigh, palm,

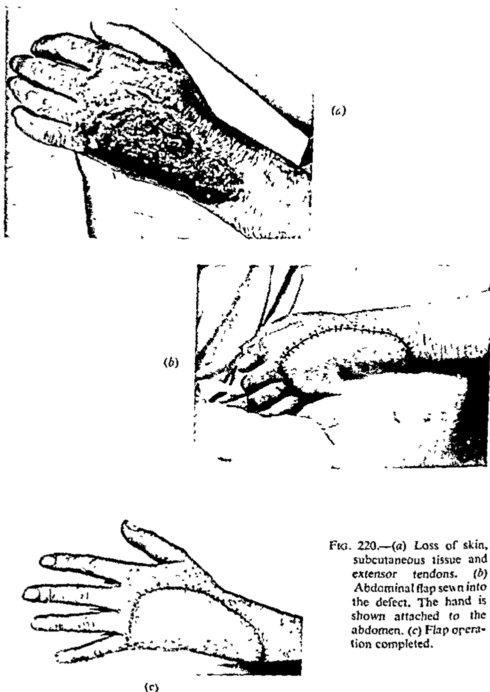


FIG. 220.—(*a*) Loss of skin, subcutaneous tissue and extensor tendons. (*b*) Abdominal flap sewn into the defect. The hand is shown attached to the abdomen. (*c*) Flap operation completed.

or opposite forearm, and considerable care is necessary in their design and trimming to ensure survival, with good functional and aesthetic results. (Fig. 221 (a), (b) and (c).)

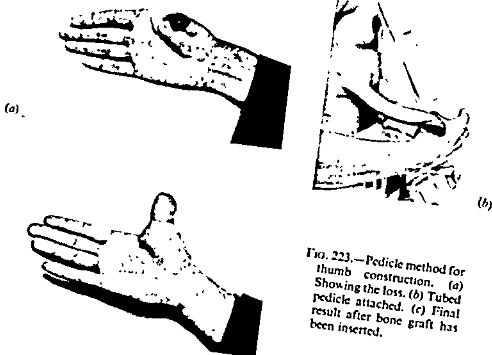


FIG. 223.—Pedicle method for thumb construction. (a) Showing the loss. (b) Tubed pedicle attached. (c) Final result after bone graft has been inserted.

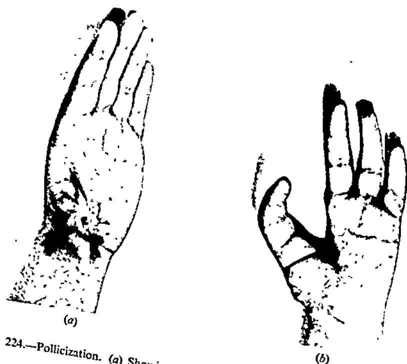


FIG. 224.—Pollicization. (a) Showing the loss. (b) The index finger transplanted.



FIG. 222(a).—Volar skin loss with exposure of flexor tendons.



FIG. 222(b).—A skin flap has been cut from dorsum of the middle finger.



FIG. 222(c).—Showing the skin flap sewn into the defect. The donor surface on the dorsum of the middle finger is covered with a split-skin graft.



FIG. 222(d).—The flap has been completely detached from the middle finger and transferred to the index finger.

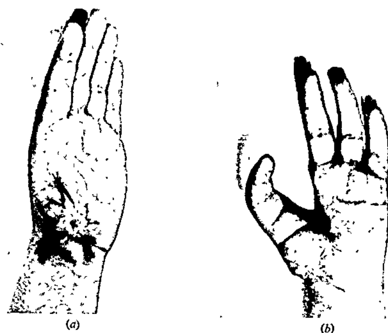
(3) Pollicization

Pollicization is the transplantation of a finger into the position of a thumb. Either the index or middle finger can be used; good mobility and normal sensation should result.

(a) (b)

(c)

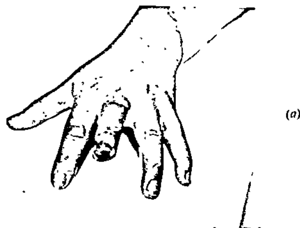
FIG. 223.—Pedicle method for thumb construction. (*a*) Showing the loss. (*b*) Tubed pedicle attached. (*c*) Final result after bone graft has been inserted.



(*a*) (*b*)

FIG. 224.—Pollicization. (*a*) Showing the loss. (*b*) The index finger transplanted.

Method A dissection is made between index and middle fingers, separating all structures which are proper to each, including the nerve fibres in the median branch to the second cleft. The vascular supply is retained intact, and the extensor



(*a*)



(*b*)



(*c*)

Fig. 225.— Finger-tip reconstruction. (*a*) Showing the loss. (*b*) Thenar flap raised and sewn into the defect on the finger. (*c*) Two weeks later. Flap detached from the palm and inset into the finger completed.

tendons are freed from their neighbours and from their synovial attachments to the wrist. The metacarpal is dislocated from the carpus, 3 centimetres are removed from the base, and the stump is transposed and wired on to the first metacarpal stump, in 120 degrees of rotation, opposition, and 45 degrees of abduction from the hand axis. (Fig. 224 (a) and (b).)

If the first metacarpal is absent the base of the second is articulated with the trapezium and the distal phalanx is amputated, leaving a normal-length thumb. This method, by preserving sensation and multiple joint motion, is advisable in the majority of cases. It is a single-stage procedure, as the defect left on the radial side of the next finger is made good at the same time by a thick split-skin or Wolfe graft.

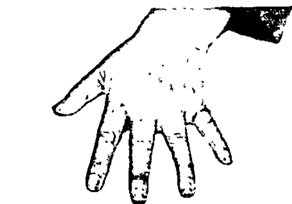


FIG. 225(*d*).—Finger-tip reconstruction. Result. Note normal contour.

(4) Pulp losses

Pulp losses demand immediate repair if chronic infection and painful finger-tips are to be avoided. Small skin losses are repaired by Wolfe grafts taken from the ulnar border of the palm, and larger skin losses by similar grafts from the upper arm. Wherever pulp substance is destroyed it should be replaced, and for this purpose a flap of skin and subcutaneous fat is transferred from the thenar eminence by a two-stage procedure in vascular continuity. (Fig. 225 (a), (b), (c) and (d).)

When deformed or painful scars are already present they should be excised and replaced as soon as possible by this method, for they are a potent cause of trophic change in the finger.

(5) Tendons

Many tendon reconstructions are worth doing given suitable standards of technique and after-care. Joints capable of passive movement can be made to function by appropriate tendon grafts or transfers. There is copious literature on this subject but, atraumatic technique, complete haemostasis and the use of non-irritating suture material are the three essentials for success.

(6) Joints

Joint stiffness may be due to intracapsular, capsular or extracapsular causes and an exact diagnosis must be made before surgical treatment is considered.

Joint operations on the proximal and distal interphalangeal joints are notoriously uncertain, but there are two procedures worth considering on the metacarpo-phalangeal articulations. When metacarpo-phalangeal movement is limited by capsular shortening due to disuse or oedema the following operation may result in full function. *Capsulrhaphy*

Through a bilateral approach each collateral ligament is carefully removed in its entirety. (Fig. 226, Ic.)

A flap of periosteum, 1 centimetre long over the dorsum of the metacarpal, is cut with its base at the synovial reflection. (Fig. 226 IA and B.) The joint is then flexed and the periosteal flap moved down to lengthen the posterior

capsule, leaving a small defect over the metacarpal proximal to the joint. (Fig. 226 II.) The joint is maintained in full flexion for a few days until the reaction has subsided, and active movements are then commenced.

Arthroplasty

With cartilage destruction and intracapsular adhesions or union a fair range of movement can be obtained in these joints from arthroplasty. The

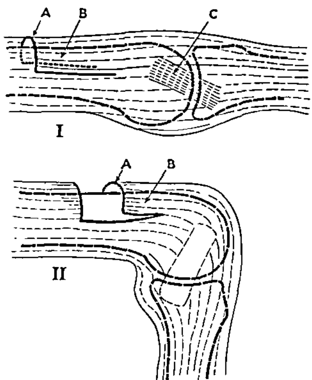


FIG. 226.—I. Capsulorrhaphy. Incision A in the periosteum outlining flap B which is based on the capsular fibres. Diagonal shading C represents collateral ligament which is excised.
II. The joint is moved into flexion and the periosteal *flap moves distally, preventing capsular rupture during* the manipulation, and leaving the defect remote from the joint.

metacarpal head is resected back, reshaped and covered either with a Vaseline gauze or with a piece of ear cartilage trimmed to fit the surface. Post-operative traction in flexion and careful supervision of post-operative exercises are necessary.

Arthroplasty is also performed on the carpo-metacarpal joint of the thumb with resultant mobility.

BIBLIOGRAPHY AND REFERENCES

Congenital defects

Kanavel, A. B. (1932). *Arch. Surg., Chicago*, **25**, 282.
Snedicor, S. T. (1940). *J. Amer. med. Ass.*, **114**, 2542.

Tendon repairs

Bunnell, S. (1922). *Surg. Gynec. Obstet.*, 35, 88.
— (1928). *J. Bone Jt Surg.*, 10, 1.
— (1938). *Ibid.*, 20, 269.
— (1941). *Ibid.*, 23, 240.
— (1944). *Surgery of the Hand*, p. 277. Philadelphia; Lippincott.
Iselin, M. (1945). *Chirurgie de la main*, p. 124. Paris; Masson.
Pacher, W. (1939). *Arch. Orthop. Mech. Ther.*, 40, 93.

Infections

Grossmark, G. J., and Plewes, L. W. (1945). *Brit. med. J.*, 1, 906.
Kanavel, A. B. (1925). *Infections of the Hand*. Philadelphia; Lea and Febiger.

Thumb reconstruction

Bunnell, S. (1931). *Surg. Gynec. Obstet.*, 52, 245.
Dial, D. E. (1939). *J. Bone Jt Surg.*, 21, 98.

Arthroplasty

Patterson, R. (1933). *J. Bone Jt Surg.*, 15, 249.

[References to other titles are given under Hand in the Index Volume. The subject is also dealt with under the heading of Hand Diseases and Deformities in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 171.]

HARELIP AND CLEFT PALATE

See FACIO-MAXILLARY INJURIES AND DEFORMITIES

HEART AND PERICARDIUM

By OSWALD S. TUBBS, F.R.C.S.

Thoracic Surgeon, St. Bartholomew's Hospital; Assistant Surgeon, Hospital for Consumption and Diseases of the Chest, London

PART I

PERICARDIUM

PAGE

PART II

HEART

PART I
PERICARDIUM
1. ACUTE SUPPURATIVE PERICARDITIS

(1) Definition

179.] Acute suppurative pericarditis is the term applied to the formation of pus within the pericardial sac as a result of invasion by pyogenic bacteria.

(2) Aetiology

Suppurative pericarditis is an uncommon condition which may occur in the course of a septicaemia or pyaemia, or in association with pneumonia which is, frequently, already complicated by empyema. Rarely, infection of a traumatic haemopericardium is the cause of the suppuration. Pyogenic infection of the pericardium is a relatively frequent terminal event but these cases are not of any surgical interest.

(3) Pathology

Pneumococci, staphylococci and haemolytic streptococci are the bacteria most commonly responsible for suppurative pericarditis. In those cases secondary to intrathoracic infection it is probable that the bacteria reach the pericardial sac by direct extension rather than by the blood stream, as it is otherwise difficult to explain the higher incidence of this complication when the empyema is on the left side. *Bacteric*

Pyogenic infection of the serous pericardium is followed by the formation of an effusion which becomes progressively more purulent. As the fibrous pericardium is of limited elasticity the pressure within the sac rises in proportion to the amount of fluid present and to the rapidity of its development; it is frequently sufficient to interfere with diastolic filling of the heart ("cardiac tamponade") so that the venous pressure rises and the systemic blood-pressure falls. *Large effusion cause "cardiac tampon*

The pus tends to collect behind, below and on either side of the heart which, therefore, remains close to the anterior chest wall.

(4) Clinical picture

Precordial pain and an increase in temperature and pulse rate in a patient already ill from a blood-stream infection or an intrathoracic infection are suggestive of spread to the pericardial sac. At this stage the diagnosis is likely to be confirmed by the presence of pericardial friction. *Precord pain an pericard friction*

The subsequent effusion usually results in the gradual disappearance of the friction sounds. With further fluid formation, cardiac tamponade may be recognized by pallor, slight cyanosis, increasing breathlessness, distension of the neck veins, a progressive fall in blood-pressure and a paradoxical pulse. The area of cardiac dullness at this time is increased and the cardiac impulse is obscured although it may be possible to distinguish the apex beat medial *Cardiac tampon*

to the left lateral border of cardiac dullness. The heart sounds are distant.

Collapse of left lower lobe

In many cases signs of collapse or consolidation of the left lower lobe are present, due to compression of the bronchus.

It is possible for a purulent effusion to develop in the pericardial sac without any local symptoms. Any deterioration in the general condition of a patient suffering from a blood infection or an intrathoracic infection should, therefore, lead to a careful examination to exclude suppurative pericarditis as the cause.



Fig. 227.—Skiagram of the chest showing typical shadow due to pericardial effusion. The shadow to the right of the superior mediastinum is due to a paratracheal abscess.

(5) Special aids to diagnosis

X-ray signs and electrocardiographic changes

Radiography of the chest after the development of pericardial fluid will show the heart shadow to be globular in form and increased in all diameters. (Fig. 227.) If the patient's condition permits of fluoroscopy, greatly diminished cardiac pulsation will be observed on screening. The normally acute cardio-hepatic angle may become obtuse (Fig. 228), but this is the exception rather than the rule.

The electrocardiogram characteristically shows low-voltage curves and inversion or flattening of the T-waves in all leads.

Pericardial paracentesis

The diagnosis can be verified by pericardial paracentesis. This operation is carried out by one of three alternative routes (Fig. 229).

(a) Upwards and backwards in the angle between the xiphisternum and the left costal margin.

(b) Directly backwards through the fourth or fifth interchondral space at least one inch from the



Fig. 228.—Skiagram of the chest of a case of suppurative pericarditis secondary to a left-sided lung abscess and localized empyema which have been drained. In this case the cardio-hepatic angle is obtuse.

lateral border of the sternum so as to avoid damage to the internal mammary vessels.

(c) Backwards and slightly medially through the fifth intercostal space lateral to the nipple line.

The first method is the best as there is less likelihood of reaching the heart with the needle and there is not any risk of transgressing a free pleural space.

(6) Differential diagnosis

Distinction from cardiac dilatation

In a patient who is seriously ill, cardiac dilatation may closely resemble pericarditis with effusion. In cases of dilatation the pulse is not paradoxical, the heart sounds, which often show gallop rhythm, are less faint than in a pericardial effusion, and the heart shadow in a chest skiagram is not globular in form. The two conditions should be readily distinguished by electrocardiography.

The nature of the effusion can be determined with certainty only by paracentesis which is, therefore, usually desirable before recommending operative treatment.

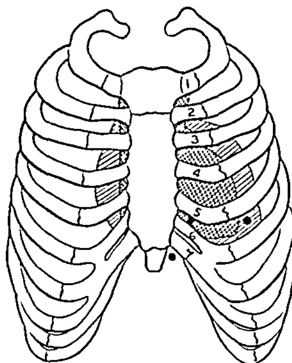


FIG. 229.—Diagram to show the sites of skin puncture for pericardial paracentesis.

(7) Prognosis

Fatal prognosis of undrained cases

Purulent pericarditis is a serious complication usually arising in a patient already dangerously ill from other causes. The combination of severe toxaemia and progressive cardiac tamponade almost invariably proves rapidly fatal in untreated cases. Even with surgical drainage the mortality is high (about 50 per cent), but those cases due to pneumococcal infection have a better prognosis than those of streptococcal or staphylococcal origin (Shipley and Winslow, 1935).

(8) Indications for surgical intervention

The place of penicillin in treatment

If pyogenic infection of the pericardial sac is recognized sufficiently early, the effusion may be serous; pericardial paracentesis followed by penicillin instillation may then result in absorption of the fluid without its ever becoming purulent. This treatment should not be instituted or continued if the fluid is purulent as some cases of undrained pyopericardium have been reported in which constrictive pericarditis has later occurred.

Early drainage recommended

With the above exception, operative drainage is indicated as soon as the

diagnosis is made. Delay until the pus becomes thick, which is properly recommended with pleural empyema, has no rational basis in the case of pericardial suppuration. The patient is never too ill for drainage as there will be immediate improvement in cardiac function when the pus is allowed to escape.

(9) Operative technique

Pericardiotomy

Local analgesia

This operation is performed under local analgesia; alternative methods of pericardiotomy are described below. The epigastric operation provides the better drainage, but the pericardium is more easily and widely exposed by the anterior approach.

(i) *Through an epigastric or costo-xiphoid approach.*—This operation is made easier if the patient is horizontal with the back arched over a pillow, but orthopnoea may make this impossible.

Skin incision

Through a subcostal or high paramedian incision the posterior rectus sheath is exposed just to the left of the xiphisternum and is then separated from the costal margin. By developing this plane directly upwards the diaphragm is detached from its origin in this region and the pericardium is exposed. A small opening is made in the pericardial sac so that the pus escapes slowly, thereby avoiding acute dilatation of the heart due to a sudden increase in venous return.

Exposure and opening of pericardium

With relief of the intrapericardial pressure the patient's condition will show obvious improvement. After enlarging the opening in the pericardium, a large soft drainage tube is placed so that the end is just within the pericardial sac.

(ii) *Through an anterior approach.*—With the patient in the semi-sitting position a curved incision is made, starting along the left lateral border of the sternum from the level of the third costal cartilage to that of the fifth space whence it is carried laterally over this space. After separating the muscle fibres from the fourth and fifth costal cartilages, the latter are resected and the intervening intercostal tissues are removed. The internal mammary vessels are ligated at the upper and lower end of the incision and the fibres of transversus thoracis are excised or swept laterally, care being taken not to open the pleural cavity. The pericardial sac is then opened, with the precautions previously described, and finally the whole of the exposed area of pericardium is either marsupialized to the deep fascia or excised, thus providing a wide opening for drainage. Some surgeons advise against using any drainage material (Strieder and Sandusky, 1941), but the pus tends to pool inferiorly behind the heart, and the writer prefers to pass a very soft rubber tube under the diaphragmatic surface of the heart and to use this for the instillation of penicillin subsequently.

Skin incision

Opening in the pericardium

The wound is packed very lightly with warm moist gauze after protecting the margins with Vaseline.

(10) Post-operative care

The patient is nursed in the sitting position. The tube placed at operation in the pericardial sac is used for daily instillation of, say, 50,000 units of penicillin in 5 cubic centimetres of solution at body temperature. Most of this will

be lost in the dressings but it is probable that some will remain in the "pool" behind the heart.

The tube should not be removed until the discharge is minimal and there is evidence that the pericardial sac has been obliterated; such evidence may be obtained from skiagrams following the introduction of iodized oil through the tube. Subsequently the wound will heal by granulation.

(11) Results of treatment

The mortality reported in staphylococcal and streptococcal cases has been in the region of 60 per cent, but the conditions preceding the pericarditis are partly responsible for this high death rate. Infection with pneumococci is much less lethal.

Those patients who recover after free drainage rarely suffer subsequently from chronic pericardial disease (Bigger, 1939b).

2. CHRONIC CONSTRICTIVE PERICARDITIS

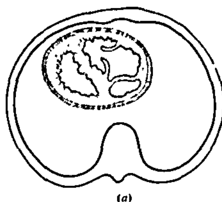
(1) Definition

Chronic constrictive pericarditis is the term applied to fibrous thickening and loss of elasticity of the pericardium due to a chronic inflammatory process. The heart thus encased is normal in size and structure. The associated clinical syndrome is characterized by a rise in venous pressure, enlargement of the liver, ascites and, frequently, by peripheral oedema.

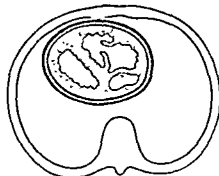
(2) Aetiology

The nature of the inflammatory process which is responsible for the callous thickening of the pericardium often cannot be proven, but it is almost certain that tuberculous infection accounts for nearly all cases (Blalock and Burwell, 1941).

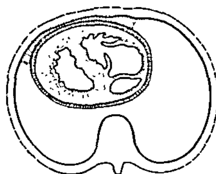
Tuberculosis as cause



(a)



(b)



(c)

FIG. 230.—Diagrams to illustrate the various forms of chronic pericardial disease. (*a*) Simple adherence between the two layers of serous pericardium. (*b*) Chronic constrictive pericarditis. Showing gross thickening of the two pericardial layers. (*c*) Mediastino-pericarditis.

Suppurative pericarditis treated without drainage has been reported to develop subsequently into constrictive pericarditis, but this is exceptional as death usually occurs before a chronic stage is reached.

B.S.P. 4—27

Rheumatic infection not responsible

Rheumatic infection is rarely, if ever, the responsible agent, for rheumatic pericarditis, although causing adhesions between the serous layers, is not followed by thickening or loss of elasticity of the membrane (White, 1935).

(3) Pathology

There has been great confusion regarding chronic disease of the pericardium which is reflected by the multiplicity of descriptive labels (adherent pericardium, adhesive pericarditis, concretio cordis, Pick's syndrome, obstructive pericarditis and so on). (Fig. 230.)

In order to clarify the pathology it is necessary to emphasize that simple obliteration of the pericardial sac by adhesions does not materially interfere with cardiac function. Such adhesions do not produce symptoms or signs during life and are usually an incidental finding at necropsy.

Mediastino-pericarditis

Cardiolysis (Brauer)

In the past, cases of gross cardiac enlargement have been attributed to "pericardial adhesions". In order to provide an adequate mechanical explanation for the cardiac enlargement, adherence between the fibrous pericardium and the anterior chest wall (chronic mediastino-pericarditis) has been described. It was claimed that this necessitated indrawing of the chest wall with each contraction of the heart, and that this interference with systole was responsible for progressive cardiac hypertrophy. Mobilization of the chest wall by resection of the ribs and cartilages overlying the heart (Brauer's operation of cardiolysis) was recommended in order to diminish the burden. It is almost certain that the cardiac enlargement in such cases is due to intrinsic valvular disease (usually rheumatic in origin) and that the pericardial adhesions have not been a factor in the enlargement. Systolic retraction of the chest wall does not have to be explained by extrapericardial adhesions as it is commonly seen with gross hypertrophy of the heart in the total absence of pericardial disease.

True constrictive pericarditis

In true constrictive pericarditis there is gross fibrous thickening of the pericardium. Frequently, the fibrous tissue is laid down like a sandwich with an inner layer which may be separable only with difficulty from the heart muscle, coronary vessels and epicardial fat; occasionally this stratum has extensions actually into the heart muscle. This layer may be distinguished from an outer and thicker one by a plane which represents the original site of the serous sac. This plane may be recognized by the presence of cheesy material or of plaques of calcification or by the fact that there is a more or less readily discoverable plane of cleavage between the two layers of fibrous tissue. Occasionally small pockets of pus which may contain tubercle bacilli are found. Although calcification is common it is certainly not an essential feature of constrictive pericarditis.

Active tuberculous infection

In a few cases the pericardial thickening is due to an obvious active tuberculous inflammation with typical tubercle formation. Such cases have often been preceded by a tuberculous effusion into the pericardial sac and occasionally into other serous membranes as well (polyserositis).

Chronic cardiac tamponade

The heart is essentially normal in structure and size, but, being encased in fibrous tissue, it cannot expand normally in diastole so that the venous return is impeded. The clinical syndrome of chronic cardiac tamponade follows. There is a generalized rise in venous pressure leading to congestion and

enlargement of the liver, and this is usually followed by ascites. If the congestion of the liver persists cardiac cirrhosis commonly ensues and further increases the ascites. The spleen may also be enlarged, but its increase in size is relatively less than that of the liver. Congestion of the kidneys is frequently responsible for persistent proteinuria. Peripheral oedema usually appears considerably later than do hepatomegaly and ascites. The lungs may show healed or even active tuberculous lesions; pulmonary congestion is not a marked feature of the disease until its terminal stages. The pleurae may be chronically inflamed due to old tuberculous infection; effusions into the pleural cavities may also be seen as transudates secondary to the venous stasis.

(4) Clinical picture

Patients with constrictive pericarditis are most commonly seen between the ages of 10 and 40 years. The initial complaint is usually of a painless swelling of the abdomen. This is followed by swelling of the legs and, at this stage, a mild degree of breathlessness may be noticed. In the absence of treatment these symptoms increase until the patient becomes bedridden. *Swelling of the abdomen*

Surprisingly, it is often impossible to obtain a past history indicating the time of onset of the pericardial infection; the explanation probably lies in the fact that tuberculous pericarditis can appear as a very mild illness.

In a completely different category are those patients who have been under observation with a florid tuberculous pericarditis with effusion or even polyserositis, and who show signs of persistent venous stasis after the effusion has been absorbed.

On examination slight cyanosis may be observed. The superficial veins in the neck remain full with the patient sitting upright. The pulse is paradoxical and of low tension and volume; in some cases it is totally irregular due to auricular fibrillation. The cardiac impulse is diminished or absent. The apex beat, which may be difficult to localize, is usually in the normal position and remains there even with change in the patient's posture. *Signs of chronic cardiac tamponade*

The area of cardiac dullness is little, if at all, enlarged and the heart sounds are decreased in volume but otherwise normal. *Small quiet heart*

The blood-pressure is lowered, particularly that in systole, so that the pulse pressure may be less than 20 millimetres of mercury. Signs of an old pleurisy or of pleural effusion may be present, but added sounds originating from the lungs are more likely to be due to a tuberculous lesion than to congestion.

The liver is enlarged, often down to the umbilicus, and the spleen may be palpable. The amount of ascitic fluid varies from none at all to enormous quantities causing great protuberance of the abdominal wall and eversion of the umbilicus. Peripheral oedema is a later manifestation of the venous stasis but may ultimately increase to massive proportions; it is often particularly marked in the scrotum.

Proteinuria is commonly present.

The main features, therefore, are a "quiet" heart showing little or no enlargement, venous distension, hepatomegaly, ascites and a low blood-pressure. *Main features*

(5) Special aids to diagnosis

Venous pressure and circulation time

Clinical evidence of a raised venous pressure may be confirmed by direct estimation; the normal figure of 75–120 millimetres of water may be more than doubled.

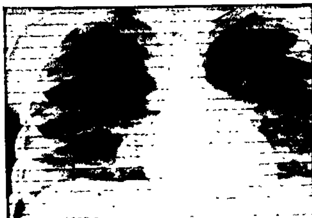
The arm–lung circulation time by the ether method (normal 3–10 seconds) is prolonged, due to the venous stasis.

Radiological examination

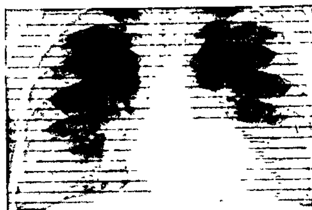
In skiagrams of the chest, the heart shadow may actually be smaller than the expected normal; on the other hand, slight enlargement due to the thick pericardial covering is not uncommon. If there is considerable enlargement, constrictive pericarditis is unlikely to be the correct diagnosis.

If calcification of the pericardium is present, this will be well shown in films—using high penetration; it is often best seen in one of the oblique views.

Fluoroscopy is by far the most valuable aid to diagnosis as limitation of cardiac movement due to the inelastic pericardium is readily demonstrable. This reduced pulsation can be recorded by kymography. (Fig. 231 (a) and (b).)



(*a*)



(*b*)

FIG. 231.—(*a*) Kymograph of case of constrictive pericarditis. The faint serrations along the outline of the small heart shadow record the greatly diminished cardiac movements. (*b*) Kymograph of same case after pericardiectomy. The heart shadow has enlarged to the left and the serrations along the left border are much deeper than before operation, due to the increased pulsation.

Electrocardiograms

The electrocardiogram characteristically shows low voltage curves with flattening or inversion of T-waves in all leads.

The plasma-protein level may be diminished because of malnutrition, chronic liver congestion, loss of protein in ascitic fluid and proteinuria.

(6) Differential diagnosis

(i) *Congestive heart failure.*—When due to disease of the heart or its valves, congestive heart failure should be readily distinguished from constrictive

pericarditis by local signs of such disease. Many cases of constrictive pericarditis are missed because the venous congestion is falsely assumed to result from an intrinsic cardiac lesion. This would be avoided if pericardial fibrosis was generally recognized as the probable explanation for the signs of congestive failure in those patients without enlargement of the heart or evidence of valvular disease.

(ii) *Cirrhosis of the liver, tuberculous peritonitis and other intra-abdominal lesions causing ascites.*—Such diagnoses are sometimes made in cases in which ascites is due to constrictive pericarditis; this error would not occur, however, if extra-abdominal signs of constrictive pericarditis were sought for in every case of chronic ascites.

(iii) *Superior vena caval obstruction.*—This should be readily recognized by the fact that the venous stasis is limited to the upper half of the body and by the absence of ascites and hepatomegaly.

(iv) *Polyserositis.*—This is a rare condition in which there is effusion into several or all of the serous cavities. Hepatomegaly and a raised venous pressure are not features of polyserositis unless cardiac tamponade is present as a result of a massive pericardial effusion, in which case there will be clinical and radiological evidence of gross distension of the pericardial sac.

(7) Prognosis

The activities of a patient with constrictive pericarditis are always limited, but to a very variable degree. Some are totally bedridden and the signs of congestion increase until death ensues within from one to two years of the onset of first symptoms. Others have to limit their exertions but are able to perform a sedentary occupation for a decade or more.

Prognosis variable

(8) Indications for surgical treatment

Operation should be recommended in all cases with the following exceptions:

(a) Those patients having a long history (more than 5 years) and with mild symptoms which show little or no progression. This applies particularly to those over the age of 40 years, especially if auricular fibrillation is present.

(b) Those with evidence of active pulmonary tuberculosis.

(9) Pre-operative management of the patient

(*a*) *Rest*

Those patients with peripheral oedema will improve considerably after a period of rest in bed. On the other hand, it is preferable that a patient should not be completely confined to bed in the immediate pre-operative period.

(*b*) *Diet*

The transudation of fluid can often be decreased by restricting the fluid intake by mouth to 40–60 ounces per day; a similar result can be obtained by limiting the sodium chloride ingested without restricting the fluids.

Restriction of fluid or salt

Those patients with diminished plasma proteins should be fed with a high protein diet or given protein hydrolysates.

(*c*) *Mercurial diuretics*

These are most valuable in reducing the waterlogged state of the patient; 2 millilitres of injection of mersalyl, given intramuscularly twice weekly,

usually prove satisfactory. A test dose of 0·5 millilitre should be used initially as severe reactions have been known to occur with the full dose.

The diuresis is probably greater when the urine is acid; it is, therefore, preferable to give ammonium chloride (30 grains) by mouth three times on the day of injection.

(d) Digitalis

Those cases with auricular fibrillation should be maintained on a dose of digitalis sufficient to keep the ventricular rate near normal figures. This drug is not of value in the absence of auricular fibrillation.

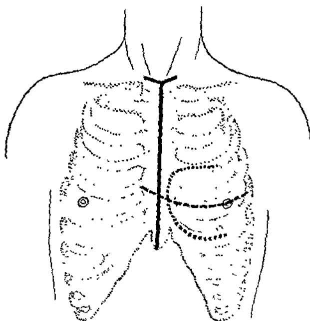


Fig. 232.—Diagrams illustrating three different incisions used to expose the heart.

(e) Paracentesis abdominis

Ascitic fluid sufficient to cause uncomfortable abdominal distension and diminished diaphragmatic movement should be drained through a cannula at intervals depending on the rate of its formation.

(f) Paracentesis thoracis

Those few cases with sufficient pleural fluid to impair respiration should be treated by aspiration, particularly on the day before operation.

(10) Operative technique

Pericardiectomy (Délorme)

General anaesthesia

This operation is usually done under general anaesthesia, and ether is probably the best drug to employ for this purpose as it does not cause cardiac irritability.

Administration through an intratracheal tube is advisable in case both pleural cavities are accidentally opened during the operation.

Intravenous infusion is contra-indicated as it further increases the venous congestion.

Elevation of the head end of the operating table helps to decrease congestion in the head and neck.

Methods of exposure

The best method of exposure has not yet been settled. Any one of the following will give adequate access (Fig. 232):

(i) Transpleural antero-lateral thoracotomy through the fourth intercostal space with division of the fourth and fifth costal cartilages. The exposure can be increased if necessary by division of the third and sixth costal cartilages.

(ii) Resection of the fourth and fifth costal cartilages with about one inch of the corresponding ribs through a semicircular incision based laterally.

(iii) Complete median sternotomy.

(iv) Transpleural postero-lateral thoracotomy through the sixth rib bed.

The second method has the disadvantage that the chest wall overlying the heart will always remain pliant.

The second and third methods aim at an extrapleural approach, but the pleura is frequently torn when being stripped from the pericardium to which it may be very tightly adherent. Actually, a communication between the wound and the left pleural cavity is an advantage for it allows any sero-haemorrhagic exudate which may collect in the post-operative period to escape into the pleural cavity from which it can be aspirated.

The object of the operation is to excise the pericardium encasing the ventricles; the area excised must extend at least down to the diaphragm below, as far as the phrenic nerve on the left and up to the auriculo-ventricular groove above and to the right. The left ventricle should be freed of its pericardial covering before the right ventricle in order that it may be prepared to receive the increased blood flow resulting from decortication of the right side (Schmieden and Westerman, 1937). Often the pericardium is least adherent to the heart in the region of the apex which is, therefore, a good starting-point for the resection. *Object of operation* *Area of pericardium excised*

The pericardium is picked up and carefully incised down to the heart muscle or epicardial fat; the fibrous covering is then gradually separated from the heart muscle by blunt dissection, except where the density of adherence necessitates the use of scissors, but special care must be taken to avoid damage to the coronary vessels. *The ease of separation varies enormously.* As damage to the heart muscle may occur in difficult cases, it is preferable to raise the pericardium in strips, leaving one end attached until the ventricles have been completely freed; by this method an attached flap of pericardium is always available to aid in repairing any damage to the heart (Churchill, 1936). *Separation of pericardium from heart*

Frequently it is possible to recognize two layers of fibrous tissue which can be separated along a plane representing the original site of the pericardial sac; it is essential that the inner layer should be removed as well as the outer covering (Sellors, 1946). *Thickened pericardium in two layers*

When the ventricles have been freed from their encasement the heart will herniate forwards and to the left, a process which is assisted if the inferior surface of the heart is separated from the diaphragmatic layer of the pericardium.

The chest is then closed; if the pleural cavity has been opened the left lung is inflated by the use of positive pressure by the anaesthetist before the pleural cavity is sealed off from the atmosphere.

(11) Post-operative care

Oxygen should be given from the time the patient leaves the theatre and continued for at least 24 hours. *Oxygen*

The patient should be nursed in the semi-sitting position as this relieves the congestion.

If the pleural cavity has been opened, blood-stained fluid may collect in it and require aspiration. *Paracentesis thoracis*

In some cases there is an immediate rise of blood-pressure and diuresis starts at once; in others this result is slower in appearing and the pre-operative

measures employed to remove oedema fluid may need to be continued for a period.

(12) Results of treatment

If the ventricles have been adequately freed the venous congestion and its sequelae will entirely disappear so that the patient suffers no further symptoms. Failure to achieve a successful result may be due to insufficient freeing of the heart, in which case further operative treatment must be considered.

Persistent ascites

Sometimes, especially in those cases with a history exceeding two years before operation, complete relief is obtained except for persistence of the ascites. In this case the ascites may be due to cirrhosis of the liver consequent upon the prolonged hepatic congestion.

Reactivation of tuberculosis

If there is active tuberculous infection in the pericardium at the time of its removal, sinuses may develop in the wound although many such cases heal well. Reactivation of tuberculous lesions elsewhere and death from miliary tuberculosis have both been reported.

PART II

HEART

WOUNDS OF THE HEART

(1) Pathology

The heart may be damaged by crush injuries but surgical treatment is limited to penetrating wounds caused by missiles or stabbing. Such wounds are usually followed by bleeding into the pericardial sac (haemopericardium) although very small fragments may pass right through the heart without causing haemorrhage.

If the opening in the pericardium is large the blood escapes freely to the exterior, but some of it may pass into the pleural cavity, especially on the left side. In either case the effects of massive haemorrhage ensue.

Tamponade by haemopericardium

If the wound in the pericardium does not afford a free exit for the blood, the intrapericardial pressure rises rapidly so that the heart is compressed and diastolic filling is prevented. Such tamponade, which may occur with as little as 100–200 cubic centimetres of blood in the pericardial sac (Elkin, 1941), will, of course, stem the flow of blood from the wound in the heart.

In those patients who survive the direct effects of the injury, infection may subsequently convert a haemopericardium into a pyopericardium, particularly in wounds due to retained missiles.

(2) Clinical picture

Patients with heart wounds who reach medical attention present a combination of three clinical syndromes: (1) shock, (2) haemorrhage and (3) cardiac tamponade.

The typical story of tamponade is as follows:

Typical history of tamponade

A wound is received and followed by immediate gross external blood loss but the patient remains conscious and often active. After a few minutes, during which the intrapericardial pressure rises until it is sufficient to prevent

further filling of the heart, consciousness is lost and bleeding diminishes. This is followed by a period of stupor or great restlessness. At this time the patient is cold, pale, cyanosed and sweating. The arterial pressure is low and often cannot be measured, but the venous pressure is high so that the neck veins are prominent. The heart sounds are muffled or absent but the area of cardiac dullness is not appreciably increased because so little blood in the pericardial sac is sufficient to compress the heart.

If there is a large opening in the pericardium communicating with the pleural cavity, there will be signs of massive intrapleural haemorrhage. A splashing sound accompanying cardiac contractions indicates the presence of air as well as of blood in the pleural cavity due to an associated injury of the lung (Bigger, 1939a). *Intrapleural haemorrhage*

(3) Special aids to diagnosis

(a) Fluoroscopy, preferably with a portable apparatus, is invaluable in recognizing cardiac compression as the heart shadow appears almost immobile under such conditions. The heart shadow is not appreciably increased in size so that skiagrams are useless in the diagnosis of tamponade, but they may be of value in demonstrating the presence and position of retained foreign bodies and the amount of intrapleural haemorrhage. *Fluoroscopy invaluable*

(b) The venous pressure should be measured by direct estimation to assess the degree of tamponade. The progress of the cardiac compression can be judged by repeating this at frequent intervals.

(4) Prognosis

The mortality rate from heart wounds treated surgically is less than 50 per cent (Elkin, 1941), whereas only 10 per cent of untreated cases recover (Fischer, 1868). Injuries by missiles causing free external or intrapleural bleeding are more frequently fatal than stab wounds.

(5) Indications for surgical treatment

(a) Heart wounds with massive intrapleural or external haemorrhage should be submitted to *immediate* operation if the bleeding is still active.

(b) In those patients with tamponade, the blood should be aspirated from the pericardium by the costo-xiphoid route (*see* Acute Suppurative Pericarditis). If the compression recurs the process should be repeated; further recurrence indicates the necessity for immediate operation. *Aspiration of haemo-pericardium*

(6) Pre-operative management of the patient

All cases should be treated for shock and haemorrhage. Transfusion, or infusion of other fluids if blood is not available, may be life-saving. Tamponade is not a contra-indication to this as there is evidence that a further rise in venous pressure may restore cardiac filling and even obviate the necessity for operation (Blalock and Ravitch, 1943).

(7) Operative technique

General anaesthesia as recommended for pericardiectomy (*see* p. 422) is advisable as it is essential to have a quiet patient.

The approach to the heart depends to some extent on the site of the external

wound, but, generally speaking, the first method of exposure recommended for pericardiectomy—transpleural antero-lateral thoracotomy through the fourth intercostal space—should prove satisfactory. In those cases without pleural injury, this approach may be modified by resecting the fourth costal cartilage and adjacent portion of rib, and stripping the pleura from the chest wall and pericardium until the costo-mediastinal pleural reflection can be retracted laterally.

Extrapleural approach if pleura not wounded

If visible the wound in the pericardium can be enlarged to expose the heart; otherwise a long incision is made between stay sutures. Blood and clot are then removed with a sucker.

Wounds of ventricle

Bleeding from a ventricle can usually be controlled by digital pressure upon the wound while sutures are passed through the muscle under the finger and subsequently tied (Beck, 1942). If the injury is not readily accessible a stay suture passed through the apex may be used to steady the heart and rotate it when necessary to expose the wound (Ballance, 1920).

Wounds of auricle

Haemorrhage from a wound in an auricle is preferably controlled with a clamp such as that employed for the pulmonary artery in Trendelenburg's operation of embolectomy; the wound can then be sutured.

When the bleeding has been controlled, the pericardial sac is cleansed and any foreign material removed.

The aperture in the pericardium should be left open or sutured loosely in order to avoid recurrence of tamponade.

A wide communication with the pleural cavity, if not already present, should now be made so as to provide a form of internal drainage (Griswold and Maguire, 1942).

Finally the chest wall is carefully closed.

(8) Post-operative care

Morphine is used to control restlessness. Oxygen is given in the early post-operative period.

Blood which collects in the pleural space should be removed by aspiration.

Pericardiotomy may be required if infection occurs in the pericardial sac (*see* Acute Suppurative Pericarditis).

(9) Results of treatment

Those patients who survive usually have normal cardiac function unless a coronary vessel has been occluded, in which case there may be a corresponding area of myocardial infarction.

Foreign bodies coming to rest within the chambers of the heart may form emboli: those lodged in the heart muscle may be responsible for cardiac pain and intramural clotting; such clot may become infected. The indications and technique for the removal of foreign bodies have been described in full by Harken (1946).

REFERENCES

Ballance, C. A. (1920). *The Bradshaw Lecture on the Surgery of the Heart.* London; Macmillan.
Beck, C. S. (1942). *Ann. Surg.*, **115**, 698.
Bigger, I. A. (1939a). *J. thorac. Surg.*, **8**, 239.
— (1939b). *Ann. Surg.*, **109**, 763.

Blalock, A., and Burwell, C. S. (1941). *Surg. Gynec. Obstet.*, **73**, 433.
— and Ravitch, M. M. (1943). *Surgery*, **14**, 157.
Churchill, E. D. (1936). *Ann. Surg.*, **104**, 516.
Elkin, D. C. (1941). *Ann. Surg.*, **114**, 169.
Fischer, G. (1868). *Arch. klin. Chir.*, **9**, 571.
Griswold, R. A., and Maguire, C. H. (1942). *Surg. Gynec. Obstet.*, **74**, 406.
Harken, D. E. (1946). *Surg. Gynec. Obstet.*, **83**, 117.
Schmieden, V., and Westerman, H. H. (1937). *Surgery*, **2**, 350.
Sellors, T. H. (1946). *Brit. J. Surg.*, **33**, 215.
Shipley, A. M., and Winslow, N. (1935). *Arch. Surg., Chicago*, **31**, 375.
Strieder, J. W., and Sandusky, W. R. (1941). *New Engl. J. Med.*, **225**, 317.
White, P. D. (1935). *Lancet*, **2**, 539 and 597.

[References to other titles are given under Heart and Pericardium in the Index Volume.]

HERNIA

By JULIAN TAYLOR, O.B.E., M.S., F.R.C.S.
SURGEON, UNIVERSITY COLLEGE HOSPITAL; SURGEON, NATIONAL HOSPITAL, LONDON

GENERAL INTRODUCTION

Scope of the text

180.] These pages are addressed to surgeons, yet it is hoped that, as an important part of their content is devoted to prognosis, they may be helpful to general practitioners, for there are few families completely free from this common and disabling malady. Details of surgical technique have been eliminated as far as is possible, such discussion being restricted to occasions when technical methods may be thought to control prognosis, to favour success or to prevent it. For full descriptions of operative methods, their varieties and sub-varieties, readers are referred to works on operative surgery in which they may be found in profusion; for the developmental background recourse should be had to the surgical text-books.

The different varieties of abdominal hernia—inguinal, femoral and ventral—are discussed in turn.

PART I

INGUINAL HERNIA

1. INTRODUCTION

It has been known for many years that a large number of the operations performed for the relief of inguinal hernia are inadequate, and the experiences of two wars have served rather to stress the widespread persistence of disquieting failure than to give unequivocal assurance of progress. In World Wars I and II and in all the Services the frequency of recurrence after operation for hernia in young, healthy, and athletic subjects has caused much seemingly unnecessary invalidism, and this has been the impotent concern of administrative authority. Nevertheless progress has been made and inguinal hernia is becoming less and less the living material for the training of the apprentice, more and more the interest of the trained surgeon.

Between World Wars I and II the figures of Sir Max Page and others disclosing the results of the treatment of hernia in the Metropolitan Police Force, roused instant misgiving, for they revealed that among those picked subjects a recurrence rate of about twenty per cent might be expected. It is certain that for operators all over the British Isles the recurrence rate, as computed at the beginning of World War II, is not less than twelve per cent. *Rate of recurrence* A conception widely held is that a potent cause of recurrence is the performance of repairs of the Bassini type (1890), and some surgeons have believed that, at least in young subjects, removal of hernial sacs may be the only necessary curative measure. Disappointment has followed, however, and the devising of new procedures has continued. Of all these the most valuable is probably that of Gallie who proposed the use of grafted fascia, adding to our resources a technical method that is of wide application, and that now has an established place in the surgery of many parts of the body. *Gallie's operation* (*See* Fascial Grafts in Vol. 4, p. 70.)

As the treatment of hernia is preponderantly operative it is well to state here the essentials of the chief procedures in use, and then to discuss the nature of recurrence and the probable principles of its prevention, for success is unlikely to be attained without study of failure.

2. THE PRINCIPAL OPERATIVE PROCEDURES THAT HAVE BEEN ADVOCATED SINGLY OR IN COMBINATION

The following is a summary of the operative procedures advocated.

(1) Removal of the sac.

(2) The strengthening of the posterior wall of the inguinal canal by sewing the conjoint tendon to the reflected part of the inguinal ligament.

(3) The closure or obstruction of the incontinent internal abdominal ring.

(4) The reinforcement of the posterior wall of the inguinal canal by means of fascial flaps and grafts.

HERNIA

By JULIAN TAYLOR, O.B.E., M.S., F.R.C.S.
Surgeon, University College Hospital; Surgeon, National Hospital, London

GENERAL INTRODUCTION

Scope of the text

180.] These pages are addressed to surgeons, yet it is hoped that, as an important part of their content is devoted to prognosis, they may be helpful to general practitioners, for there are few families completely free from this common and disabling malady. Details of surgical technique have been eliminated as far as is possible, such discussion being restricted to occasions when technical methods may be thought to control prognosis, to favour success or to prevent it. For full descriptions of operative methods, their varieties and sub-varieties, readers are referred to works on operative surgery in which they may be found in profusion; for the developmental background recourse should be had to the surgical text-books.

The different varieties of abdominal hernia—inguinal, femoral and ventral—are discussed in turn.

PART I

INGUINAL HERNIA

as the slight moisture so often seen in the tropics, and by others again as suppuration, or even as frank suppuration (whatever the last expression may mean). Accepting as conveying the fact of wound infection all descriptive modulations from ambiguous delicacy to uncompromising confession, it is clear that in herniotomy suppuration in some degree is regrettably common. The difficulty of assessing its incidence is increased by the long delay that may occur before it is manifest, amounting sometimes to many years when unabsorbable stitches have been used. *Difficulty of assessing incidence*

(5) The anatomy of recurrence

(a) Oblique recurrent sacs

The commonest form of recurrence is the appearance of a new oblique sac, entering the canal through an internal abdominal ring that may be the natural one unclosed by operation or may be a newly formed breach. Such sacs, when herniotomy has been performed by others, are often considered to have been regrettably unremoved. A slightly kinder interpretation supposes the existence of an unnoticed second sac, for double hernial sacs are occasionally seen in inguinal hernia. Recurrent oblique hernia is so common, however, that neither contempt for predecessors nor charitable anatomical excuse is appropriate. An oblique recurrent sac, after entering the inguinal canal, follows the course of the original one, and it is remarkable that a newly formed peritoneal process can so penetrate the dense scar tissue that results from opening the inguinal canal by operation. *The occurrence of double hernial sacs*

(b) Direct recurrent sacs

Recurrence also occurs in the form of sacs of the direct variety, joining the cord to the medial side of the inferior epigastric vessels and being so placed whether the original hernia was direct or indirect. Such direct sacs may be large and pass from canal to scrotum, or may be small bulges of peritoneum through repaired posterior walls that have subsequently given way. It is perhaps in contemplation of these direct recurrences, following operations for oblique inguinal hernia, that the Bassini repair has been canonically condemned by some authorities. *Site of sac*

(c) Bulging of the whole region of the inguinal canal

This discouraging form of recurrence is fortunately not so common as either of the first two named.

When the surgeon considers the foregoing anatomical varieties of failure, he should contemplate in planning an operation for inguinal hernia the following aims, giving to each its appropriate value in relation to his clinical examination of the patient he is proposing to treat. *Planning of operation*

4. AIMS OF OPERATION

The aims of operation may be summarized as:

(1) The removal of the hernial sac.

(2) The closure of the internal abdominal ring which is usually dilated.

(3) The strengthening, where necessary, of the posterior wall of the inguinal canal—that is, the reinforcement of the fascia transversalis. Alternatively, one of the methods in which the inguinal canal is obliterated may be chosen.

(4) The preservation or restoration of the natural muscular closure of the inguinal canal in so far as this may be possible.

(5) The reinforcement of the posterior wall of the inguinal canal by the insertion of foreign bodies such as wire filigrees or gauze, silk, or nylon.

(6) The destruction of the inguinal canal.

Strengthening local abdominal musculature

With all methods, restoration of power to the local abdominal musculature may be thought to be a necessary measure, being an aspect of treatment that naturally came to the fore in the armed Forces during World Wars I and II, and that has recently been especially in demand in the universal call for rehabilitation.

3. RECURRENCE AFTER OPERATIONS FOR INGUINAL HERNIA

It is hard to imagine a malady in which the success of operative treatment may be more clearly assessed, for the variables are few and the failures frequent. Nevertheless discussion rages and surgeons must still regard Radical Cure with the cautious reserve that an optimistic adjective engenders when used to qualify a surgical procedure.

The following facts and opinions regarding recurrences may be thought to be of importance in helping surgeons to decide on appropriate operative procedures.

(1) Age and sex

Importance of anatomy

Failure is common in patients of both sexes and at all ages from adolescence on, but the older the patient the greater is the likelihood of failure. It is not so often seen in females as in males, probably because the round ligament, having no organ to support, is a small muscular cord made fast in the groin. In the male the spermatic cord—the vascular pedicle of the testis—is bulky and also has a supporting function. When there is a slack, toneless abdominal wall the cord transmits the weight of the testicle directly to the region of the internal abdominal ring, the natural opposition of cremasteric tone and mural friction in the canal being insufficient in such cases to prevent excessive strain at the critical point—the internal abdominal ring. This is especially true when the testis is for any reason enlarged, and in cases of hydrocele.

The internal abdominal ring

(2) The date of recurrence

Failure is often manifest within a year of an operation for hernia, but it is also frequently seen after intervals of five or more years. Recurrence may take the form of a slowly increasing bulge, or it may appear suddenly.

(3) The bodily health of patients

Recurrence is favoured by advancing years, by obesity, by chronic cough, by metabolic disease, and by all causes of acquired hernia, of which, in the elderly male, an important one is urinary obstruction with consequent straining at micturition. It is probably also favoured by rapid reduction of weight in an obese person unaccompanied by increase in muscular power.

(4) The healing of herniotomy wounds

The role of suppuration

Suppuration is a common precursor of recurrence but one whose frequency it is hard to assess, since surgeons have differing conceptions regarding what constitutes suppuration for the purpose of record. Thus infection of operation wounds may be described by some as ligatures coming out, by others

of the fibres. The sac of the hernia will then be found on the supero-medial aspect of the assembling normal structures of the spermatic cord. Attention to this obvious anatomical fact renders unnecessary any destructive search for the sac. The sac should be removed deep to the internal abdominal ring, and in so doing it should be remembered that the vas deferens is normally adherent to the peritoneal sac at this point. Gentle dissection may easily isolate it but, should there be great thickening in a long-standing hernia, considerable care may be needed. Nearby are the inferior epigastric vessels lying to the medial side of the ring and behind the transversalis fascia. They do not give rise to difficulty unless the case is one of recurrent hernia and a plastic procedure has been unsuccessfully carried out in this region. In one such operation puncture of the inferior epigastric artery resulted in severe intraperitoneal haemorrhage, fortunately recognized on account of the onset of pain in the shoulder before the patient's condition had greatly deteriorated.

Care if thickening is present

(*b*) *Treatment of large sacs*

In general it is better to divide the neck of a large sac and to leave undisturbed the distal part, especially if there has been either pressure due to a truss, or irreducibility in the past, since sacs so irritated become adherent and their removal may result in effusion of blood.

(*c*) *Isolation of the spermatic cord*

On first exposure the cremaster muscle is seen to be continuous with the internal oblique muscle, and the sac is sought by splitting the muscle between its fibres as described. If it is decided not to carry out any plastic procedure, or merely to close the internal abdominal ring, the cremaster should be left undisturbed except for the small opening already described. Should a posterior reinforcement of the canal wall be proposed, however, the cord must now be separated from its surroundings, a procedure that must necessarily detach the cremaster from its inguinal attachments except at its origin. Before closure of the wound the split made in the cremaster should be repaired.

Posterior reinforcement of canal wall

(*d*) *The ilio-inguinal nerve*

After opening the canal the ilio-inguinal nerve should be looked for and its course noted. It lies on the internal oblique and then on the cremaster and passes through the external abdominal ring with the rest of the cord. Sometimes, however, it passes through a special foramen in the external oblique fascia and sometimes also in more than one trunk. Its recognition and isolation from the operative repair of the hernia present no difficulty, except in cases of recurrent hernia when a dissection may be necessary to display it and to separate it from scar tissues. It must always be respected while closing and repairing the hernia, especially when closing the external abdominal ring, for injury to it may cause unpleasant neuralgic pain or paraesthesia in or near the scrotum.

The course of the nerve

Ease of recognition and isolation

Effects of injury

(*e*) *The external oblique aponeurosis and the external abdominal ring*

The external oblique aponeurosis should be closed and the external abdominal ring restored to its normal size, neither step having any apparent effect in the prevention of recurrence.

(1) The removal of the hernial sac

Removal of the sac is a necessary step in oblique hernia, though sometimes the surgeon may prefer to divide and ligate it at its neck. The removal of a large sac from the spermatic cord is apt to cause bleeding, and a haematoma may result. It is rare that the distal part of a sac left *in situ* causes any trouble though occasionally a hydrocele may form. In direct hernia, when a sac is confined to the inguinal canal and has no neck, removal may be unnecessary.

Position of scar

It is usually considered advisable to remove an oblique peritoneal sac sufficiently freely to leave the resulting scar well on the peritoneal side of the internal abdominal ring. When a direct sac passes through a small opening in the transversalis fascia the sac should be similarly removed. Difficulty during excision of the sac is only encountered when, owing to secondary thickening of the extraperitoneal tissue, the sac is tightly fused with both the peritoneum and the internal abdominal ring. A so-called pathological ring is thus formed, which may sometimes be a cause of strangulation. It is almost invariably seen also in recurrent hernia, then being due to scarring from the earlier operation.

A result of operative scarring

(2) The closure of the internal abdominal ring,
(3) the strengthening of the posterior wall, and
(4) the preservation of the natural muscular closure of the inguinal canal

The mechanism of closure

These are matters that cannot be considered separately nor without contemplation of the natural closure of the inguinal canal. This mechanism has attracted the attention of many writers, yet it remains something of a mystery, though the work of Lytle (1945), on the subject of the internal abdominal ring, has done much to clarify it. The terminology in use is not always helpful, attempting, as it sometimes does, to make clear by comparison with homely things. One may ask, for example, what is meant by "the shutter action of the internal oblique", for it is open to question whether there is anything in the inguinal canal that has likeness to any kind of shutter. There is crescentic thickening of the medial side of the internal abdominal ring, yet is it necessary to assume that it is in fact the sling that it may resemble?

Natural thickening of fascia

Nevertheless, we know that the internal abdominal ring does enlarge medially in most hernias, and indeed may be so big that an anatomically indirect hernia may be functionally direct. A thickening of the fascia on the medial side of the ring may thus be expected as one element in the natural attempt at prevention of the formation of a hernial sac. We know also that with large sacs, especially those with irreducible contents, the musculature is feeble and unpromising, the conjoint tendon frail and distant from the inguinal ligament, the transversalis fascia stretched, feeble, and maybe split. It is certain that the normal closure of the inguinal canal is a nicely adjusted mechanism of stresses and supports, the incompetence of any part of which may cause breakdown with the appearance of hernia; it is probable, however, that the predominant factor in the production of inguinal hernia is not the same in every case. There are many similar mechanical problems in the body; for example, those of the pelvic floor and the support of the kidney.

A mechanism of stresses and supports

(5) Steps common to most operations for inguinal hernia

(a) Excision of sac and treatment of the cremaster

Exposure of sac

An inguinal hernial sac may be exposed after opening the canal by splitting the cremaster muscle, near its origin from the internal oblique, in the direction

be closed adequately it is probable that the posterior wall of the canal does not need support from any plastic procedure.

(a) Closure of the incontinent internal abdominal ring

The closure of the incontinent internal abdominal ring has been attempted in several ways:

(i) *By closure, with stitches, of the opening in the transversalis fascia* (Fig. 233).

(ii) *By closure as in* (i) *together with transference of the neck of the peritoneal sac* and the structures of the cord a distance of about 2 centimetres laterally, so that the former is no longer opposite the internal abdominal ring. The transference may be effected by cutting the internal oblique muscle parallel

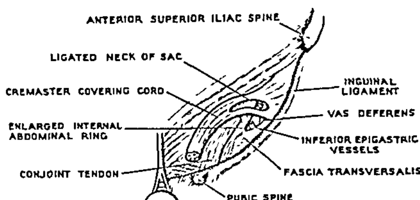


FIG. 233.—Diagram showing typical findings in a young man. The internal abdominal ring is slightly enlarged medially. The cremaster has been incised and the neck of a sac divided and ligated. The spermatic cord is retracted upwards. External oblique not shown. Ilio-inguinal nerve not shown. The closure of such an incontinent ring is easy and may be all that is necessary.

to the inguinal ligament, displacing the neck of the sac and the cord at its assemblage 2 centimetres laterally, anchoring the neck in its new position and finally closing the transversely divided internal oblique fibres on the medial side of the cord. This manoeuvre is advocated by some surgeons, but to the writer it seems to be unnecessary and harmful, since the injury to muscle fibres neglects the need to preserve muscular function at its best. Another method which has been advocated is to separate the testis from its scrotal bed, to make a large split in the internal oblique, lateral to the ring, and to draw the testis and cord through this opening, subsequently replacing the testis in its proper position. Again, this seems to the writer to involve unnecessary trauma, and he is not certain of the efficacy of changing the normal anatomy in this particular way.

The need to preserve muscular function

(iii) *By plastic or grafting procedures.*—Fascial suture may well be employed in closure of the internal abdominal ring, and for this purpose, unless the ring be enormous, a large enough strip can easily be cut locally. A strip, 5 millimetres wide, is split from the medial margin of the divided external oblique aponeurosis. This strip extends from the pubic bone, on which it is left based, to the point some 12–14 centimetres away, at which the muscle fibres give place to fascia. In cutting such a strip care must be exercised

Fascial suture

5. PRINCIPLES OF SOUND SURGERY FOR INGUINAL HERNIA

It is impossible for the writer to have had personal experience of all the varieties of procedure that have been suggested in the treatment of hernia; he can do no more than state views regarding the principles by which operators should be guided, and indicate his own conclusions. Most operations for inguinal hernia are compromises with anatomical perfection, and their success depends not only on their design but also on the skill with which they are carried out. Thus an expert and thoughtful surgeon will achieve success by whichever compromise he chooses.

Compromises with anatomical perfection

(1) In infants

The presence of an inguinal hernia in a newly-born infant may be regarded as evidence of delay in the closure of the funiculus that normally occurs towards the end of intra-uterine life. The efficient application of a truss results, *in a large number of cases, in postponed closure, by the end of the first year of* infancy. Success depends on continuous wear, the variety that is usually most satisfactory being the rubber horseshoe of which two are obviously necessary so that one can be worn in the bath, and can then be replaced by the dry one. The growth of the average baby during the first year entails the replacement of the first pair by a second, but a third is usually unnecessary. Sometimes, although the truss prevents the filling of the sac by abdominal contents, obliteration fails to occur. In such a case the subject is likely to suffer from a manifest inguinal hernia at a later date and often this has an apparently sudden onset. When trusses fail, as for instance when infants are fretful owing to poor but affectionate parental control, operation should not be delayed.

Delay in closure of the funiculus

Possible failure of obliteration

Operations in infancy.—The inguinal canal in babies is so short in comparison with its calibre that infantile hernias seem to pass straight forwards from the internal to the external abdominal rings. Nevertheless, the operative removal of these sacs without plastic procedure is uniformly successful in spite of the apparent incompetence of the canals. The performance of these operations does not seem to disturb infant feeding, rather it may transform fretful, ill-nourished babies perpetually in discomfort into contented infants. When babies have bilateral hernia there is no objection to operating on both sides at the same time. The results are uniformly successful.

No disturbance of feeding

(2) In children between the ages of six months and puberty

Operation should be undertaken as soon as the diagnosis is made. It should take the form of a simple excision of the hernial sac, and there is no objection to bilateral operation at one sitting. The results are uniformly successful.

Immediate operation

(3) In adolescents and young adults

Recruits for the Services are included in this group, and undoubtedly in these cases the results of sac excision alone have been unsatisfactory. The reason for failure is probably to be found in uncorrected patency and incontinence of the internal abdominal ring. In addition to removal of the sac, therefore, some kind of closure of this opening is necessary. In young people who have good musculature and are slim the transversalis fascia is usually a strong well-developed structure, and thus if the internal abdominal ring can

Uncorrected patency and incontinence of ring

the same time our solicitous concern for the fate of the delicate tissues that we are stitching, as refinements of Bassini's original conception. *Refinements of Bassini's operation*

(c) *The use of fascial suture in young subjects*

If one has used fascial closure of the ring, as suggested in the last section, it is easy and convenient to use the same strip of fascia for the Bassini closure as illustrated diagrammatically in Fig. 234. We owe to Gallie the knowledge that autogenous fascia makes a perfect suture of the bulky kind, unequalled by any other. In this repair we are using fascia as a satisfactory suture material and not as a piece of new tissue to replace a defect. The procedure is therefore properly named fascial suture. It is an anatomical compromise suitable for patients whose tissues are in good condition and whose conjoint tendons may be expected to respond satisfactorily to being brought down to the inguinal ligament. *Autogenous fascia*

In selecting a procedure for any example of inguinal hernia, the surgeon should be guided by the states of the internal abdominal ring, of the musculature including the conjoint tendon, and of the transversalis fascia. At his *Selection of procedure*

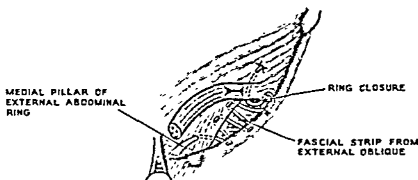


FIG. 234.—Diagram showing compromise operation. A strip of external oblique fascia is used as a suture for bringing the conjoint tendon to the inguinal ligament and for closure of the internal abdominal ring.

examination of the patient before operation he should determine the functional state of the ring, whether the hernia has to be coughed down or whether it reappears so soon as the patient assumes the erect position, and whether it can be retained by digital pressure over the ring. If it cannot be so retained, the hernia is either a true direct one, a variety not very uncommon in young people, or the ring is so big that the hernia is functionally direct though anatomically indirect. If at operation there are found enlargement and incontinence of the ring and any fragility of the transversalis fascia, that is to say, if there is need for a reinforcement of the Bassini type, the writer prefers to use the fascial suture described, the internal abdominal ring being closed with the same strip. The use of such a strip adds neither to the severity nor materially to the duration of the operation. The fixation material which he prefers is either the so-called serum-proof silk or linen thread. *Direct of indirect hernia* *Choice of fixation material*

This operation has the theoretical disadvantage that it displaces the conjoint tendon downwards and puts strain upon it. It has been in use without ring closure, however, for over forty years since it was first proposed by McArthur (1904), and it has an established place. When the conjoint tendon is extremely

Mode of use

regarding the ilio-inguinal nerve, the course of which through the aponeurosis must be clearly seen before designing the fascial suture. The strip may be used in several ways, but so far as ring closure is concerned an attractive imitation of the normal anatomy may be achieved by the procedure illustrated in Fig. 234. One limb of a U-shaped loop is fixed to the inguinal ligament, deep to the internal oblique muscle and lateral to the existing ring, the bend of the U is brought round medially to the point of assembly of the cord, and the other limb fixed to the deep surface of the internal oblique in a position corresponding to that of the first limb, but 2 centimetres supero-medial to it and the inguinal ligament. The inserted strip may be considered to assume the function of a new looped tendon passing medially to the point of assembly of the cord. Further, it may be presumed to move laterally with contraction of the internal oblique muscle, and thus it may obstruct the internal abdominal ring when the abdominal musculature contracts.

Possible need for plastic repair

In recent years stress has rightly been laid on the state of the internal abdominal ring, and many surgeons believe that further repair is not necessary in young, muscular patients. The idea is an attractive one and may constitute a real advance in surgical knowledge. There are many young people, however, who are not so slim, and many slightly older ones whose tissues are of doubtful vigour, and even if the theory be sound the selection of patients for ring closure alone is unlikely to be easy. Therefore the question must often arise of the propriety of making, in addition, a plastic repair of the posterior wall of the inguinal canal.

(*b*) *Reinforcement of the posterior wall of the inguinal canal*

At the present time adverse references are made to the old-established Bassini procedure of suture of the conjoint tendon to the reflected part of the inguinal ligament. Nevertheless, what is in fact closure of the internal abdominal ring was claimed by Bassini as an important part of his operation for, in his original communication, he insisted that stitches be placed laterally, as well as medially, to the spermatic cord. To the writer it seems that the need for the reinforcement of the transversalis fascia is frequently demanded by reason of its fragility, and none the less because attention has also been paid to the internal abdominal ring. Though other methods are available and will be discussed, with a frail and incompetent transversalis fascia some sort of reinforcement of the Bassini type, using living or ordinary materials, constitutes a satisfactory repair, offensive as it may be to some anatomical purists of the present day. The facts are well known, that many recurrences of hernia follow operations of the Bassini type, that they may take the forms of new oblique sacs passing through old or newly-formed rings, and that they may also be direct with the giving way of reinforced posterior canal walls. If the former variety be seen it may be that the operator disobeyed Bassini's instructions by omitting to place his stitches as Bassini recommended, thus failing to close the ring. In instances of the latter variety, it may be that his stitches were so cruelly inserted as to produce necrosis in their grips, as a result of excessive tension. It is true that Bassini did in fact recommend the use of large stitches gripping masses of tissue, but perhaps we may forgive a surgeon of the 1880s for what we now know to be, in general, a poor technique. We may regard the modern assessment and closure of the ring, and at

Failure to place stitches correctly

knuckle of peritoneum, covered by extraperitoneal fat, is bulging (Fig. 236). The closure of such slits is easy, being effected by means of a few stitches in the transversalis fascia. Where direct hernias are of the nature of the more serious bulges permitted by very weak fascia, however, procedures of the kinds discussed in the next section are to be preferred (Fig. 237).

(5) In the middle-aged, the old, the obese, in those with poor musculature, in patients having large sacs and in those who have suffered recurrence

As regards age, there is hardly any age so great that it prohibits treatment of a disabling hernia. The principal real contra-indication is enormous size in the hernia, when return of the hernial contents to an abdomen already overloaded with omental and mesenteric fat may occasionally provide an insoluble problem. Even the benefits of modern anaesthesia are obviously transient and the strain thrown on such a repair during convalescence is very great. *Principal contra-indication*

It is clear that the sole use of either or both of the plastic procedures so far discussed, ring closure and Bassini reinforcement, must result in tension and therefore must be rejected in all these cases. The principal operative procedures that have been advocated singly or in combination all aim at closure of the ring and strengthening of the canal wall without tension. Closure of the ring does not present a much more serious problem in these cases than it did in the younger group already discussed. Reinforcement of the posterior wall of the inguinal canal may be achieved by fascial grafting, by the use of whole-thickness skin, or by the use of bone.

(*a*) *Fascial grafting*

Strips of fascia taken from the fascia lata of the thigh may be grafted into the position of the feeble transversalis fascia. The advantages are: first, that the new posterior wall is constructed of tissue that will recover vitality, and *Advantages and disadvantages*

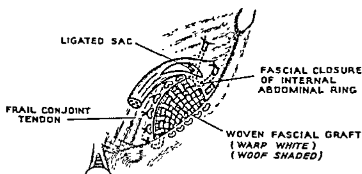


FIG. 238.—Repair of large inguinal hernia by means of fascial closure of internal abdominal ring and woven fascial graft reinforcing posterior wall of inguinal canal. The conjoint tendon is frail and the transversalis fascia thin and bulging. The graft introduces tension nowhere in the repair.

that may be of any thickness desired; secondly, that this may be fixed in its place with no tension whatever. The disadvantages are that a good deal of tissue must be taken from elsewhere as there is no adequate local supply, and

thin and displaced upwards, a large grafting operation is necessary or possibly one of the other procedures, to be described in the next section.

Two-stage operation indicated

It should be noted that no bilateral hernia needing any kind of plastic or grafting procedure should have right and left sides closed at the same operation, for the slightest tension on one side may be increased and the chances of success reduced by the slightest similar tension on the other.

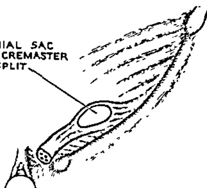


FIG. 235.—Small direct hernia seen after splitting cremaster. Sometimes direct sacs appear above the cremaster and below the conjoint tendon.

(4) In direct hernia

Incidence

This condition is not uncommon in young subjects and is even seen in those with good musculature (Fig. 235). It will often be found that there is a small slit in the transversalis fascia, through which a

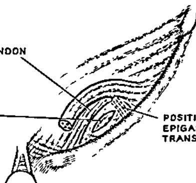


FIG. 236.—A common variety of direct inguinal hernia seen in young adults.

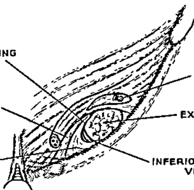


FIG. 237.—Diagram showing typical findings in a middle-aged obese man. The opening in the transversalis fascia is a large defect and the conjoint tendon is frail and displaced upwards. The large defect needs closure like that shown in Fig. 238.

Two other methods need mention.

(e) *The destruction of the inguinal canal as proposed by Halsted* (1893)

This is a very well-known and widely favoured method. After removal of the sac the spermatic cord is displaced laterally and in front of the external oblique aponeurosis, which is now used to replace the weakened posterior wall of the canal and the enlarged ring. Elsewhere in the abdominal wall, in incisional hernia for example, the posterior layers are unquestionably necessary for closure to be sound, the external oblique being quite inefficient, to which fact reference is made under incisional hernia. The placing of the cord in front of the external oblique aponeurosis does not alter the anatomy or function of the latter and the writer distrusts this repair. *Displacement of spermatic cord*

(f) *The method of Bloodgood* (1898)

In this operation an attempt is made to find locally enough tissue to strengthen the posterior wall of the canal, by turning a flap of rectus sheath cut from its lower end downwards and laterally into position. Again, this method is outside the writer's experience, but it has advocates among good surgeons and in difficult cases. It does not make use of foreign bodies and it avoids the need to open the thigh to obtain fascia. *Strengthening of posterior wall with local tissue*

6. COMPLICATIONS

(1) Irreducibility

Irreducibility may be due to adhesions between bowel and sac or omentum. In large hernias in the obese it is probably wise to remove any large masses of omentum that may be adherent. *Adhesions*

(2) Strangulation

This accident is best dealt with as a form of intestinal obstruction. The only comment that is necessary here is the obvious one that to undertake extensive fascial repairs may be unwise in the presence of strangulation owing to the duration of such operations and the increased danger of wound infection. Thus in the case of a large strangulated hernia in a fat person, it may be wise to relieve strangulation and to postpone repair until the patient is in a better state. *Extensive fascial repair contra-indicated*

(3) Interstitial prolongations of hernial sacs in the abdominal wall

These interstitial prolongations present no difficulty other than the need to make a suitable repair of the abdominal wall after their removal.

(4) Sliding hernia

When part of the colon, iliac on the left side, caecum and maybe appendix on the right, descends into a hernia extraperitoneally, partial irreducibility occurs. In all cases of long-standing inguinal hernia and especially in the obese, the possibility of the existence of such a sliding hernia must be remembered. Should the operator fail to recognize its presence, he is likely to open the bowel. On the right side with very large hernias, it often happens that not only the caecum but also the lower end of the mesentery slides down into the canal. None of these anatomical varieties occasions any difficulty in the necessary repair.

that the operation thus becomes a long and sometimes tedious one. The method of Gallie is used, enough fascia being taken to permit the weaving of a new sheet of tissue to form the new posterior wall and to close the internal abdominal ring, the former part being attached to the conjoint tendon and to the reflected part of the inguinal ligament (Fig. 238). In the writer's opinion this is the method of choice and he uses none other.

The method of Gallie

(*b*) *The use of whole-thickness skin*

The dermis is obviously a ready-made sheet of strong connective tissue which is easily available. It has been used with success and its advocates say that it is unnecessary to attempt to remove the epidermis, no ill effect resulting from burying it in the operation wound. Nor do ill effects seem to ensue from the implanting of the skin appendages. The writer has not practised this method, being sufficiently conservative to prefer the now old-fashioned woven fascial graft, and the inquiring reader is referred to the writings of Mair (1945a and b).

(*c*) *The use of bone*

This is another connective tissue that has been used in hernial repair by grafting.

(*d*) *The use of large foreign bodies for the repair of hernias*

An idea has been revived from the pre-grafting days that there may be inserted into the tissues at the hernial site a large, strong and flexible foreign body, which at first may be expected to control the hernia by its own qualities, and which later, with the passage of time, may stimulate the production of scarring that may provide of itself an adequate repair in the form of cicatricial tissue. The silver-wire filigrees originally used proved unsatisfactory on account of the irritating character and the partial absorption of silver. No surgeon who has attempted to operate upon a ventral hernia that has recurred through a filigree and has become strangulated, is likely to forget the experience. The newer, more passive, materials, however, such as stainless steel and tantalum, made into filigrees, or into thin flexible gauze in the case of tantalum, serum-proof silk (that is, silk waxed or coated with a proprietary preparation), and nylon (a unifilamentous material), are said to give promise. Nevertheless to the writer there seems to be some ambiguity of intention in the use of such materials for repair. On the one hand there may be thought to exist the need for an irritated bed so that scar tissue may be produced in adequate sheets and on the other there is the search for materials that in no way irritate the tissues in which they are placed. The least irritant of materials in use at the present time is said by some people to be tantalum, by others stainless steel. Further, every surgeon knows by experience that when unabsorbed materials have been left in wounds, there is no limit to the period of time that may pass before suppuration may occur. In the writer's opinion, none of these methods has any real advantage over fascial grafting, nor does he think, though he has no personal knowledge of the newer materials other than serum-proof silk, that the new tissue produced for repair by the use of large foreign bodies is likely to be of so satisfactory a quality as that which results from fascial grafting.

Filigrees of silver wire

More passive materials

Since the introduction, late in the last century, of Lotheissen's operation by the inguinal route, no other procedure has been necessary. Indeed on its introduction his operation transformed the treatment of this hernia from a dubious repair into an entirely satisfying one, for recurrence should not follow a well-performed operation except in the variety described in the previous section, in which the hernia escapes from its proper compartment of the femoral sheath into that occupied by the vein.

Lotheissen's operation

Lotheissen's operation is so firmly established, so widely performed and so successful, that there is no need to describe it fully here. It consists in the opening of the inguinal canal, the incision of the transversalis fascia after displacing the spermatic cord upwards, the exposure and removal of the femoral sac and the closure of the femoral ring. In the writer's opinion the following details are important.

(1) The closure of the femoral ring

Possible compression of femoral vein

Alternative method

The opening may be closed by the direct method of stitching the medial end of the inguinal ligament to the pectineal ligament, the femoral vein being retracted out of harm's way during the suture. It has been objected that this closure may compress the femoral vein. Nevertheless, the space between the inguinal ligament and the pubic bone widens, as it extends laterally, in so satisfactory a way that the writer has never seen compression of the vein follow. An alternative method, whereby the conjoint tendon is brought down to the pectineal ligament, has been extensively used, but the tension resulting is considerable and it is probable that such stitches cut out. The constancy with which success may be achieved by either method suggests that the removal of the hernial sac is the important factor in the cure of femoral hernia rather than the actual method of ring closure.

(2) The bladder

The bladder may lie so close to the sac that unless it be dissected away it may be opened.

(3) The transversalis fascia

The transversalis fascia should be repaired if the method adopted for closing the femoral ring permits it.

(4) Difficulty in closure

Prevention of recurrence

Where there is found the rare variety of femoral hernia, in which the sac descends in front of the femoral vein, any plastic closure is difficult. The writer's suggestion is the introduction of a strip of fascia between the vein and the femoral canal in addition to the ordinary closure. Without some such step, recurrence is almost certain.

(5) The abnormal obturator vessels

The obturator vessels arise from the inferior epigastric vessels in two people in five. If these vessels are encountered they must be divided.

(6) Strangulation of femoral hernia

Sited at the peritoneal ring

Strangulation usually occurs at the peritoneal ring, where fascial thickening is common. The lacunar ligament is not often found to cause strangulation;

(5) Inguinal hernia with imperfectly descended testis

The repair of such hernias calls for little comment, as the management of the testis is usually the controlling factor. Should it be decided to remove the testis, an unusual procedure at the present day, complete closure of the inguinal canal is an easy and efficient operation.

7. PROGNOSIS

Consideration of each case individually

In the writer's opinion the operative treatment of every case of inguinal hernia is a specific prescription that cannot be decided by appeal to figures. The surgeon must determine the anatomical and functional changes in the patient before him, and must choose an appropriate method of restoring them to a state as near to the normal as may be possible. In contrast with the formidable numbers recorded by some authors, the writer has none of statistical value. He may perhaps be permitted to quote his experience in the discouraging circumstances of a large prison camp in the Far East during World War II. His patients numbered about forty of the most senior and the least promising prisoners, all suffering from malnutrition, some surprisingly old, some the wasted shadows of portly Dutchmen. Using in nearly every case either fascial suture or fascial grafting, there was no recurrence in three and a half years.

PART II

FEMORAL HERNIA

1. INTRODUCTION

Relative ease of management

The management of femoral hernia presents fewer problems and difficulties than does that of inguinal hernia. Unlike the internal abdominal ring, the femoral ring has little tendency to great enlargement on account of the rigidity of the structures surrounding it. The only direction in which it can enlarge is the lateral, and considerable displacement of the common femoral vein by hernia is unusual. Occasionally a femoral hernia attains large dimensions by entering the thigh not strictly through the femoral canal alone, but also in front of the femoral vein. This is the only variety of femoral hernia that presents difficulty in repair.

2. TREATMENT

Operative treatment only

No truss has been designed that controls femoral hernia satisfactorily; the treatment is therefore always operative.

(2) Protrusions of extraperitoneal fat

These protrusions of extraperitoneal fat should be excised, and the openings in the linea alba are easily closed.

(3) Umbilical hernia

(a) In infants

Small umbilical hernias are extremely common in infants, and they usually disappear spontaneously. Indeed some surgeons recommend that no treatment of the hernia is necessary, provided that the baby's digestive functions are maintained in good order. Others recommend strapping over small pads, and yet others strapping without pads. Rubber trusses are not satisfactory owing to their tendency to slip away from the umbilicus. When operations are performed for these ruptures, the results are not always satisfactory, and surgeons are well advised to resist all pressure from parents and practitioners to cut short by operation the natural process of disappearance. It is probable that such hernias are more often kept distended by crying from other causes, than that the discomfort or pain produced by them is the cause of fretfulness.

Rubber trusses unsatisfactory

(b) In adults

Umbilical hernia is common in the obese. It may pass through the linea alba in the immediate neighbourhood of the umbilicus instead of through the cicatrix itself and is thus sometimes perhaps more exactly named paraumbilical. With increasing corpulence the sac may reach an enormous size and have a great tendency to loculation in the subcutaneous fat. Fortunately the orifices in the linea alba through which they pass remain relatively small circular rings, being less than 10 centimetres across. The content of the sacs is usually omentum, transverse colon and small intestine, all of which are extremely prone to the formation of dense and complicated adhesions. For this reason they give rise to severe symptoms, and intestinal obstruction and strangulation are common. They are thus more often than not irreducible, and a huge, soft mass in deep abdominal subcutaneous fat may be mistaken for a corpulent abdomen without hernia, or possibly merely with separated recti. For this reason such patients often consult surgeons after having been provided with belts that have failed to give any sort of relief. It is a curious fact that, unless patients with large breaches in their abdominal walls have been habitually constipated, this symptom does not seem to be associated with a condition that destroys any useful power in the abdominal musculature. The only treatment is operative and, in the absence of any compelling contra-indication, this should be undertaken. The principal problem is often that of choosing an anaesthetic suitable for a fat bronchitic patient who must undergo a somewhat long operation. Many surgeons with experience of its virtues favour the use of curare.

Association with obesity

Content of the sacs

Intestinal obstruction and strangulation common

Treatment by operation

Curare in anaesthesia

3. OPERATIVE TREATMENT

These operations are often prolonged and tedious owing to the need for dissection of dense and complicated adhesions and the freeing of obstructed or strangulated loops of intestine. Before undertaking operation it is usually

Pre-operative supervision

indeed it is difficult to see how it could do so placed as it is on one side of the sac with the easily compressible femoral vein on the other. Thus to relieve strangulation an incision made in the peritoneal neck of the sac is immediately adequate. Strangulation at the saphenous opening has also been described. Should there be difficulty in reducing large hernias, division of the inguinal ligament seems to be unobjectionable. The appearance of the operative field after taking this step is not attractive, but no harm seems to result. Nevertheless, it is probable that no surgeon would take it if any way of avoiding it were discernible.

Strangulation at the saphenous opening

PART III

VENTRAL HERNIA

1. INTRODUCTION

Ventral hernia takes on the following common anatomical forms.

(1) Separation of the rectus muscles by stretching of the linea alba.

(2) The protrusion of small masses of extraperitoneal fat through holes in the linea alba, of congenital origin, especially above the umbilicus. Sometimes there is a small hernial sac into which omentum may penetrate, giving rise to symptoms of gastric disorder.

(3) Umbilical hernia.

(4) Incisional hernia.

2. TREATMENT

(1) Separation of the rectus muscles

Median bulging the only symptom

This separation is common in the obese and in those who lead sedentary lives, It rarely causes symptoms other than median bulging and is best treated, if treatment be necessary, by means of a belt.

(3) Division of muscle fibres

Where muscle fibres are divided in transverse and oblique incisions, hernia does not often follow careful closure. Where there is infection and sloughing, however, as with muscle-cutting wounds for appendicitis, hernia may well be expected. Kocher's oblique incision for exposure of the gall-bladder is well known to have little tendency to hernia formation, the space to the supero-lateral side of the incision being not more than 2 centimetres wide.

The effects of infection and sloughing

(4) Nerve section in relation to hernia formation

It is obviously undesirable to divide nerves in operations, yet there is little evidence that motor nerve section is a common factor in the production of hernia. Kocher's incision for exposure of the gall-bladder, for example, divides at least one intercostal nerve, commonly the eighth or ninth. This fact may be demonstrated at a second exposure of the biliary apparatus after an earlier operation through a Kocher's incision. A paramedian incision will then usually demonstrate that the rectus muscle throughout a part, at least, of the length of the new incision, is yellow, atrophied, non-contractile, and clearly denervated. Yet hernia is not seen unless it be a tiny one between the oblique incision and the costal margin, and clearly unrelated to the weak rectus muscle. There are only two occasions on which nerve section seems to precede the formation of a hernia. The first is common and is the occurrence of an inguinal hernia not strictly incisional in type after a McBurney's muscle-splitting incision has been made in the iliac fossa. Even in these cases the writer has been unable to demonstrate lack of function in the last thoracic nerve, which might be expected to have suffered damage in such an incision. It is highly probable that this well-known sequence is due to muscular weakness without nerve section. The other clear example is seen when, for some reason, intercostal nerves are divided far back in the loin, for instance in dealing with a war wound, or in the chest, in a thoracic procedure. In such cases there is diffuse bulging of the corresponding side of the abdominal wall.

Kocher's incision

Hernia after McBurney's incision

Nerve section can therefore be said to have little to do with the production of incisional hernia except in rare instances.

(5) Symptomatology

Upper abdominal incisional hernias are commonly symptomless apart from the presence of bulging. Lower abdominal incisional hernias, however, cause a great deal of discomfort and are liable to produce intestinal obstruction, chronic or acute, by reason of the presence of adhesions. During their evolution all these breaches in the abdominal wall tend to become ring-like openings in the parietes through which peritoneal sacs protrude into the subcutaneous tissue. Their subsequent growth and appearances, therefore, are similar to those of the umbilical hernias.

(6) Treatment

Belts are useless and provide no comfort; the treatment, therefore, is operative. In view of the facts noted, including that of the principal mechanism of production of these hernias—retraction of the oblique and transversus muscles leading to the giving way of sutures or the stretching of scars—it is clear that reconstitution of the abdominal wall by means of efficient suture

advisable to keep such patients in bed under supervision for as many days as may be necessary to attain cleanliness of inflamed skin surfaces and a satisfactory state in the bowel.

After reduction of the hernial contents and removal of the sac, closure is usually fairly easy owing to the relatively small size of the ring. The horizontal overlapping closure of Mayo has stood the test of time and is the most satisfactory method yet devised. Fascial grafting or suture is not often necessary; this is as well because fluid collections in the abdominal wall and haematoma are common post-operative occurrences, even following the maintenance of the most rigorous haemostasis. Great relief is given by these operations to obese hard-working people. Unfortunately recurrence is still regrettably common, possibly on account of the liability to the formation of haematomas and the consequent minor infections of wounds.

Fluid collections and haematomas

4. INCISIONAL HERNIA

Incisional hernia forms an interesting study, for in spite of the present stereotyped state of the approaches of laparotomy, so that when encountering a hernia in an abdominal scar the surgeon knows just what has been divided or split, the actual mode of production is not everywhere clearly understood. This is not the place to discuss at length the aetiology of incisional hernia, but there are a few important clinical facts the study of which is a necessary preliminary to success in treatment.

Mode of production not entirely understood

(1) Middle-line hernias

The linea alba seems to be prone to give way both above and below the umbilicus. The convenience of the continental practice of median upper abdominal laparotomy has brought this incision back to Great Britain with the increase in the number and scope of upper abdominal operations, completely displaced as it had been by the paramedian incision for the very reason that hernia had been found to follow it so commonly. Whether modern methods and materials used in closure, and the successful prevention of infection in operation wounds, will prevent the occurrence of another historical cycle in the placing of incisions, remains for the future to disclose. When a median incision gives rise to hernia there is a symmetrical bulge in the parietes between the rectus muscles which are thus separated from the middle line by equal distances.

Type of hernia produced

(2) Paramedian and more laterally placed incisions

When hernia follows a paramedian or more laterally placed incision, the bulge occurs not under the incision but principally to the lateral side of the skin scar. This is true of the paramedian incision, the now rare Mayo-Robson (rectus-splitting) incision, the Battle (para-rectal) incision, the oblique muscle-cutting incision and the muscle-splitting iliac fossa incision.

Position of the bulge

It is thus clear that the principal factor in the production of incisional hernia is, in most cases, the giving way of the suture line soon or late, as the consequence of the resultant force of the combined pulls of the oblique and transversus muscles. The linea alba exercises a steadying force on the unaffected side of the abdominal wall, and the rectus muscle itself, as opposed to its sheath, seems to have little influence on the formation of incisional hernias.

The principal factor in production of incisional hernia

use of fibrinogen in the wounds, just before closure, is probably a valuable measure to promote adhesion and consolidation, and to prevent the pouring out of fluid into operation areas. *Use of fibrinogen*

(1) Suture materials

The value of unabsorbable suture materials is widely discussed at the present time. The consensus of opinion seems to be that unifilamentous materials are those that have minimal tissue reaction. Stainless steel, however, is insufficiently flexible, tantalum is hard to obtain, expensive, and may not be in fact non-irritant, and nylon is hard to knot satisfactorily. Perhaps at the present time, therefore, the best material available to most surgeons is silk, which has been waxed or otherwise coated so as to earn it the name "serum-proof." Catgut is probably the most irritant of all materials, small abscesses, sterile or otherwise, being associated with its normal absorption; once absorbed, however, it has the advantage that no trace of it remains in the tissues. *Unifilamentous materials*

(2) Rehabilitation

Muscular re-education is a measure strongly to be advocated after the sound healing of all varieties of herniotomy wound. The surgeon should prescribe exercises appropriate to the operation he has performed. For example, it is unjustifiable to make a patient who has undergone an extensive dissection of his abdominal musculature get out of bed on the following day, so prejudicing the sound and strong union of the repair in order to attempt to prevent the occurrence of pulmonary embolism. It is easy to exercise the limbs and to promote the active circulation of blood in them, without putting unfair strains on large abdominal wounds. Routine physiotherapy is not to be recommended; for example, it is not desirable to institute the timed, regular exercises for all patients in a ward, that appeal to some surgeons with strong sense of discipline but possibly little imagination. *Muscular re-education* *Unsuitability of routine physiotherapy*

(3) *Surgical cleanliness*

It is with diffidence that the writer devotes the last paragraph of this article to the subject of asepsis. Nevertheless, the incidence of minor wound infections is probably as great in the wards of good surgeons as it was in those of their teachers forty years ago. No unprejudiced person may doubt that, despite the fact that surgery has progressed so far in the present century, there has been little reduction even in the best hands in the incidence of minor wound infections. Indeed there is justification for thinking that such progress as has been made has been in a retrograde direction. The old tradition of our teachers that nothing that has neither been boiled nor autoclaved should touch an open wound, is an ideal probably impossible of attainment in most operations on the viscera, and it has passed to the orthopaedic speciality in the form of a ceremonious ritual entitled the *no-touch technique*. The writer would prefer to divest it of its priestliness and to call it ordinary surgical cleanliness, a state of grace from which we should fall only when unboilable instruments, such as gloved fingers, are necessary implements, as is very commonly the case in operations on the chest and abdomen. It must be remembered that whereas, after gastrectomy, a mild stitch infection is probably no more than a trivial incident of convalescence, in the operations with which we are dealing in *Incidence of minor wound infections*

is the ideal of the surgeon. The operative treatment therefore takes the form of dissecting free the muscular and fascial components of the abdominal wall, and then reconstituting the abdominal wall so as to restore a normal anatomy. This ideal is usually achieved where there is no loss of tissue from sloughing due to infection of the original operative wound, and a satisfactory abdominal wall is the result. It follows that fascial grafting is unnecessary in most cases, as are the other expedients described in the management of difficult inguinal hernias. Nevertheless some surgeons claim success by the use either of steel filigrees or of tantalum gauze anchored in these defects, without the tedious dissections necessary to take down the abdominal wall into its components. Fascia may be useful in these cases, not so much as grafted material but as the highly satisfactory suture material that it is. Being bulky it does not tear out of the tissues and it provides admirable mattress sutures that take up a tension that the finer coapting stitches of other materials would not accept without cutting out. Placed as continuous mattress sutures the repair has something of the appearance of Victorian stay-laces, the edges of the aponeuroses at the same time being held together by small coapting stitches of other material.

Fascia as suture material

Continuous mattress sutures

There are two occasions, however, when the kind of repair described may tax the competence of the operator beyond the possibility of success. The first arises when there has been great loss of substance by sloughing, the second when there is a wide gap in the epigastric notch. Here the rectus muscles are pulled aside in their sheaths and become adherent to the costal cartilages on which they are lying. The freeing of them may involve a bloody dissection and the result may be that the tissue available for closure of the opening may be insubstantial to the degree that it will not take any strain. In each of these cases the use of a metal filigree may be the best solution of the technical problem, replacing the need for dissecting free the local components of the abdominal wall.

5. THE MANAGEMENT OF LARGE HERNIAS OF ALL VARIETIES

Pre-operative care

It is of great help to have these patients in bed under supervision for some days before operation. Their bowels can thus be brought into good order, and the chest to as near soundness as may be possible. Their skins are often in poor state from dermatitis due to sweating surfaces in prolonged contact, and it is difficult to correct this while patients are wearing ordinary clothes. In view of the prolonged and wide exposures that may be necessary in many of these cases, it is wise to give penicillin before and after operation. Haemostasis should be most accurate and electric coagulation is helpful for small vessels. The writer has already expressed a preference for curare in providing the necessary relaxation during anaesthesia. After all such operations it is the writer's practice to keep patients in bed for three weeks, so that the strain on their abdominal musculature is minimal during the healing period. It cannot be expected that grafted fascia may be revascularized, even after the lapse of this period of time, but the interval of three weeks probably allows grafts to become firmly adherent and thus to provide minimal obstruction to the progress of the new, growing blood-vessels. In this connexion the liberal

The use of penicillin

Curare in anaesthesia

HERNIA—DIAPHRAGMATIC

BY SIR THOMAS P. DUNHILL, K.C.V.O., C.M.G., M.D., F.R.C.S., F.R.A.C.S.

CONSULTING SURGEON, ST. BARTHOLOMEW'S HOSPITAL, LONDON

1. DEFINITION

181.] A diaphragmatic hernia is a protrusion of abdominal contents through the diaphragm into the thoracic cavity. Usually the protrusion is enclosed in a sac, but when a sac is not present the condition is known as a false hernia. This differentiation is of both academic and surgical interest. To earlier authors, whose knowledge was obtained from the post-mortem room at a time when operation was rarely if ever undertaken, the false variety seemed to predominate. *True and false hernias*

The term eventration is used when partial or complete interruption of a *Eventration*

The dangers of stitch infection

this article stitch infection is likely to mean failure. In the writer's opinion it is far easier to infect accidentally the wound of an incisional hernia operation, than that, for example, of meniscotomy. He has some reason for stressing the importance of keeping fingers out of wounds in operations for hernia, for in the filthy surroundings of war-time prison life, without antiseptics and without gloves, but with sterilized dressings and with boiled instruments, a number of hernia operations were carried out thus, using almost without exception, fascial suture or fascial graft. There was not a single infection even of a trivial nature amongst them. Similar and lesser procedures, however, making greater use of the fingers according to the methods of the present day, were by no means immune from these discouraging incidents. Finally, the commonness of small fluid collections in wounds, especially where scars have been excised, points in no uncertain way to the need for faultless cleanliness in the surgery of hernia.

War-time experience

BIBLIOGRAPHY AND REFERENCES

Bassini, E. (1890). *Arch. klin. Chir.*, **40**, 429.
Bloodgood, J. C. (1898). *Bull. Johns Hopk. Hosp.*, **9**, 926.
— (1919). *Ann. Surg.*, **70**, 81.
Brandon, W. J. M. (1945). *Lancet*, **1**, 167.
Gallie, W. E., and Le Mesurier, A. B. (1924). *Brit. J. Surg.*, **12**, 289.
Halsted, W. S. (1893). *Bull. Johns Hopk. Hosp.*, **4**, 17.
Lytle, W. J. (1945). *Brit. J. Surg.*, **32**, 441.
McArthur, L. L. (1904). *J. Amer. med. Ass.*, **43**, 1039.
Maingot, R. (1941). *Brit. med. J.*, **1**, 777.
Mair, G. B. (1945a). *Brit. J. Surg.*, **32**, 381.
— (1945b). *Brit. med. J.*, **2**, 178.
Tanner, N. C. (1942). *Brit. J. Surg.*, **29**, 285.
Veal, J. R. (1942). *Ann. Surg.*, **116**, 259.

[References to other titles are given under Hernia in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 470.]

present. This will be discussed more fully later. These cases belong to the group in which the attachment of the diaphragm to the parietes is defective.

Another congenital hernia lies posterior to the lower end of the sternum—retrosternal hernia (foramen of Morgagni or Larrey's space). This hernia is enclosed in a sac.

There may be defects of development in either of the domes, usually on the left but occasionally on the right side.

(2) Acquired

An acquired hernia may be non-traumatic or traumatic in origin.

(a) Non-traumatic

The most common site for acquired hernia is through the oesophageal hiatus. This is surrounded by muscle which relaxes to allow the passage of food. Stuart Harrington has shown that the elastic fibres in the tissue connecting the diaphragm to the oesophagus atrophy as age advances.

Apart from external violence, the musculature of the diaphragm is subject to the same lesions as any other muscle. Rupture of some fibres may occur—one patient who developed a hernia had been seized by a severe pain in the upper abdomen shortly before the birth of a child. An infarct may result in an area of weakness which may subsequently give way under intra-abdominal pressure.

(b) Traumatic

The traumatic hernias are usually the result of crushing injuries or penetrating wounds. In a crushing injury the broken ends of one or more ribs may injure or penetrate the diaphragm. Penetrating wounds also result from stabbing, or laceration by missiles of war.

Injury to diaphragm

If injured, but not penetrated, the area may stretch slowly. If the diaphragm is extensively torn other organs are necessarily involved and the injury may be incompatible with life, but even with smaller lesions herniation may be rapid and the symptoms severe. Very occasionally the diaphragm may be injured by the tube used to drain an empyema cavity. As my cases are drawn from civil practice few have been due to external violence.

(3) Age and sex

Congenital hernias are present at birth. Some are incompatible with life; in others life is terminated early, and in others again, though life is possible, it is often distressing on account of pain and dyspnoea.

When the defect is not such as to terminate life in infancy, the individual may lead a normal life until a later period, when symptoms appear more or less gradually. The average age of the patients with non-traumatic hernia in this series is 54 years. The youngest patient was 11 weeks old; there were 2 aged 75; 15 were over the age of 60 years.

Gradual appearance of symptoms

In 52 consecutive cases of diaphragmatic hernia of all varieties there were 41 females and 11 males. In other series which include battle casualties the incidence of males is naturally higher.

3. SURGICAL ANATOMY

Hernial sites

Arranged in order of frequency the sites of herniation through the diaphragm are:

(1) At the oesophageal hiatus.

phrenic nerve, usually the left, results in paralysis of the area of diaphragm supplied, with consequent raising of the dome. This does not constitute a hernia.

Knowledge of diaphragmatic hernia has been gained in stages. Post-mortem examinations first revealed the cause of symptoms which had puzzled physicians during the lifetime of their patients. It showed that herniation was prone to occur at certain anatomical sites, and that whereas one hernia possessed a sac, another did not. With improvement in x-ray technique cases began to be diagnosed during life, in the course of examination of the alimentary canal. Meanwhile advances in surgery and in anaesthesia made operations not only possible but desirable when symptoms became distressing. Examination of the hernias during operation has added greatly to our knowledge of their surgical anatomy and their treatment. The study of embryology has elucidated the aetiology. There is still much to learn, and some statements and opinions expressed here will require modification as knowledge increases.

2. AETIOLOGY AND CLASSIFICATION

Developmental imperfections, inequalities of pressure in the abdomen and the thorax, trauma and inflammation, may be concerned in the problems of aetiology and classification.

(1) Congenital

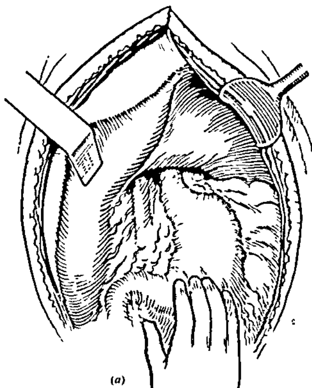
The development of the diaphragm is unusually complicated. For details of this the reader is referred to the appropriate treatises (Hume, 1922 and 1932; Keith, 1910 and 1924; Dunhill, 1935; Harrington, 1945). Suffice it here to state that the diaphragm is formed by the fusion of a number of elements; that this fusion is usually perfect; rarely it is not perfect and the resulting defect may be either one of two types. (a) At certain areas the elements from which the diaphragm is derived fail to meet and coalesce, thus leaving an opening through which the abdominal and pleural cavities remain in communication with each other, and through which abdominal viscera can herniate into the thorax during foetal life. In such cases, because the opening has never been closed by peritoneum, a hernia passing through it will not be enclosed in a sac. (b) The abdomen and thorax may be completely separated from each other, but at certain areas along the line of fusion the separation is by pleura and peritoneum only, with no interposed muscle or aponeurosis. Local absence of this interposed layer deprives the diaphragm of strength to resist stress, and thus a congenital weakness may lead to an acquired hernia. A hernia resulting from this condition will be enclosed in a sac.

Well-recognized areas of weakness

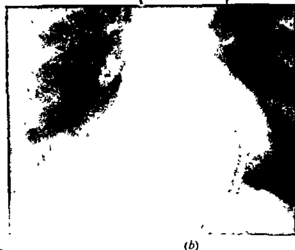
These weak areas occur in well-recognized situations in the majority of cases. One of the regions which may fail to close is the pleuro-peritoneal canal—the foramen of Bochdalek—situated dorso-laterally and usually on the left side. If this defect is limited to the foramen of Bochdalek a sac is not present. This may emerge into a broader defect with absence of muscular tissue in the costo-vertebral region. Most writers state that hernia in this larger area—due to non-development of the posterior part of the left leaf of the diaphragm—occurs without a sac, whereas in 6 cases involving this region in the present series (all adults) a peritoneal sac, itself enveloped by pleura, has been

(Fig. 242). Type 3 includes this area.

(3) There may be congenital absence of the posterior part of the left side of the diaphragm—the part which is derived from the pleuro-peritoneal membrane, together with the contribution, perhaps in varying degree, from the dorsal mesentery and the receding Wolffian ridge. I state "in varying degree" because in this series the left crus has been absent and the defect may extend from the eighth rib to the midline. This area includes type 2—the site of the more limited patency of the pleuro-peritoneal canal. Hernia through the larger defect has been the second most frequent type in my series (6 in 52, or 12 per cent). Because this defect had included the pleuro-peritoneal canal area, I had, in an earlier publication (Dunhill, 1935), classed these as "pleuro-peritoneal" and found it difficult to understand why Keith, Hume, Harrington and others



(a)



(b)

Fig. 241.—(a) Transverse diaphragmatic hernia. At operation the stomach was found in the thorax. (b) Pre-operative skiagram showing the stomach in the sac in the posterior mediastinum.



Fig. 242.—Pleuro-peritoneal hiatus.

(2) Posteriorly in the pleuro-peritoneal region—the foramen of Bochdalek. Some cases in this region come also under (3).

(3) Through a defect in the attachment of the posterior part of the diaphragm to the parietes. This larger area includes the site of type 2—the more limited patency of the pleuro-peritoneal canal.

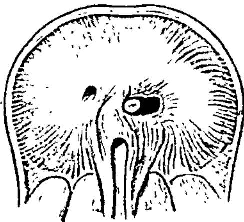


FIG. 239.—Oesophageal hiatus.

(4) Anteriorly—retrosternal—at the foramen of Morgagni.

(5) Through the left dome of the diaphragm.

(6) Through the right dome.

(7) Traumatic hernia—this may occur through any part of the diaphragm. The frequency is greatly increased in time of war.

(a) Margins of the defect

(1) In oesophageal hiatus hernia the margins of the defect are formed by the decussating muscle fibres which enclose the oesophageal hiatus (Fig. 239). This enlarges with the gradually increasing size of the thoracic loculus of the stomach (Fig. 240). A peritoneal sac is present. The hernia travels into the inferior mediastinum. It usually lies to the left of the oesophagus and bulges behind the pulmonary ligament. Sometimes the hiatus is broad, extending to both the right and left of the midline. In a previous article (Dunhill, 1935), following continental precedent, I had called this "Hernia Diaphragmatica Transversa" (Fig. 241 (a) and (b)). With this broad defect (12·5 centimetres in one case) there may have been imperfect development of the crura.

Possible defect of crura

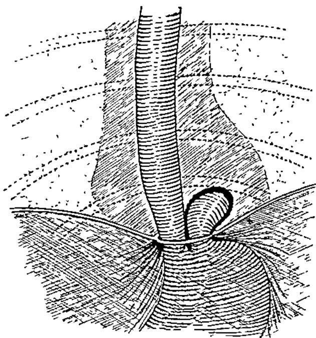


FIG. 240.—Initial stage in formation of para-oesophageal hernia.

(2) In pleuro-peritoneal hernias the pleuro-peritoneal canal fails to close, leaving a free communication—the foramen of Bochdalek—between the pleural and peritoneal cavities. For this reason a sac is not present. The margins are muscular laterally and tendinous medially

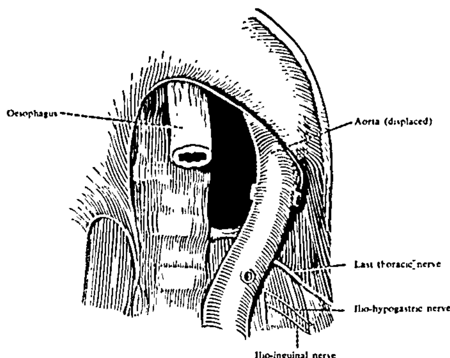


FIG. 244.—Deficiency in diaphragm arising from non-development of left crus. The aorta, not being confined to its normal position by a left crus, becomes bowed to the left.

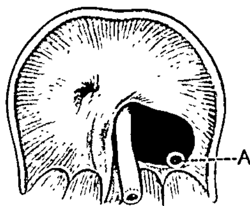
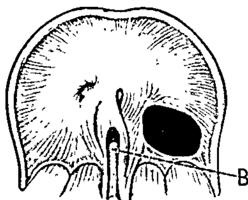


FIG. 245.—Non-development of left crus. Showing: (*a*) position of aorta (A) as found by Dunhill; (*b*) position of aorta (B) as found by Harrington.

surgeon who assisted me—can occur only through non-development of the left crus, for the aorta is normally held in the central position by two crura. A normal oesophageal hiatus is not present. The oesophagus is not supported by muscle on its left side. It lies free—as does the aorta—on the posterior parietes, behind the leaf of the broad peritoneal sac, the oesophagus to the

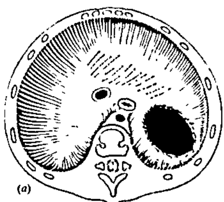


wrote that a sac was not present and few patients lived, whereas my 6 patients were all adults in late middle age and in all a well-formed sac was present. In two cases recorded by Keith (1910 and 1924), one lived beyond childhood and the other until late middle age. It is probable that these two were of the same nature as those in this series, and that every grade may exist between an opening limited to a patent canal and a defect due to a varying degree of non-development of the part of the diaphragm derived from the pleuro-peritoneal membrane and the neighbouring embryonic structures.

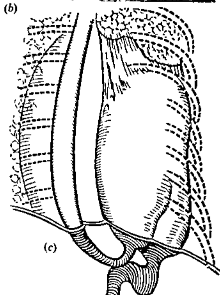
The reason for this difference in relative numbers probably lies in the sources from which information is obtained. Records from mortuaries and from hospitals for children will show a large proportion of patients dying early in life through obstruction of a hernia—without a sac—at the site of the pleuro-peritoneal canal, whereas a surgeon whose cases are drawn from a general hospital or from private practice will see a relatively greater number of patients who have lived to adult life. In hernia through a patent pleuro-peritoneal "canal" a sac is not present and the neck of the opening is restricted; whereas in hernia due to a wider non-development of the posterior part of the diaphragm the defect is large. In these, the pleural and abdominal cavities have become separated by pleura and peritoneum but muscularization of the area has been arrested. Intra-abdominal pressure has caused a hernia with a well-developed sac in this weak area. In one, previously published, case (Dunhill, 1935), the whole stomach could slide from the thoracic sac into the abdomen. The stomach was seen at an operation for gall-stones, which were found to be present and had been thought to be the cause of the symptoms. The stomach was described, some unusual appearances being noted, but it was before the days when the diaphragm was examined at operation as a routine measure and before radiologists made a practice of examining patients for hernia. A subsequent skiagram is shown in Fig. 243. Furthermore, an observation which I have not found recorded hitherto, in these cases the aorta was bowed in a long curve far to the left. At the level of the cardia the aorta was situated about 5 centimetres to the left of the oesophagus (Fig. 244). Professor Kirk (1948) points out that this considerable displacement of the aorta—confirmed on each occasion by the experienced



FIG. 243.—Showing: (1) Outline of herniated stomach, which is seen angulated over the margin of the defect in the diaphragm; (2) dome of right diaphragm; (3) abdominal portion of stomach which was permanently narrowed as described in the text.


(a)


(b)


(c)

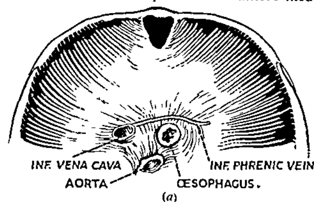

(a)


(b)

FIG. 248.—Hernia through the right dome of the diaphragm: (a) before operation; (b) after operation.

FIG. 247.—(a) Inflammatory necrosis. (b) The oesophagus is seen entering the cardiac end of the stomach, which is directed cranially. The main part of the stomach is situated in the thorax and is filled with gas. This has displaced the heart to the right. (c) Drawing to explain (b) and also showing the adhesions to the compressed lung as found at operation.

right and the aorta to the left. The condition found in my cases compared with that illustrated by Harrington (1945) is shown in Fig. 245. The margins in these cases are muscular antero-laterally, tendinous and co-terminous with the base of the pericardium antero-medially, and the neck of the sac covering the aorta, oesophagus and posterior parietes posteriorly.





(b)

FIG. 246.—(a) Retrosternal defect (foramen of Morgagni) (b) Lateral skiagram: (1) contents of sac; (2) oesophagus; (3) level of diaphragm.

(4) In the retrosternal variety herniation takes place through a more or less triangular area, the base being formed by the xiphisternum and the sides by strong musculo-tendinous tissue. The medial margin merges with the right side of the base of the pericardium. A sac is present (Fig. 246 (a) and (b)).

(5) In hernia through the left dome of the diaphragm the margins of the defect are muscular and thickened since, probably as the result of infarction or rupture of muscle fibres, the whole thickness of the muscle has given way. A sac is not present (Fig. 247 (a), (b) and (c)).

(6) Herniation through the right dome. A large defect has been encountered in this area, extending from the middle of the dome to the oesophageal hiatus (Fig. 248 (a) and (b)). The hernia was enclosed in a sac. The margins of the defect were partly muscular, partly tendinous. The hernia occupied a great part of the right thoracic cavity.

(7) In traumatic hernia the margins will naturally depend on the position of the injury.

(b) The sac

If hernia occurs in foetal life before separation of the thoracic and the abdominal cavities is complete a sac is not present. If the two cavities are

fixed in the thorax by adhesions. The patient, whose stomach is shown in Fig. 250, had a severe attack of obstruction on the last day of a sea voyage. Firm adhesions were found at operation. The skiagram was taken a year earlier, following less severe attacks.

In the pleuro-peritoneal type the *contents* are usually small and large intestine. If the posterior part of the left diaphragm is absent, stomach, colon and some small intestine are generally included. Frequently the spleen and the edge of the left lobe of the liver are drawn into the neck of the sac.

In retrosternal hernia part of the colon and often the terminal coil of the ileum are found (Fig. 251).



Fig. 251.—Arrow shows termination of ileum; caecum and portion of colon in the thorax.

In hernia through the left dome any of the above-named viscera may be present depending upon the size of the defect (Fig. 247 (b)).

In hernia through the right dome, stomach alone has been found in this series.

In herniation through a defect in the attachment of the diaphragm to the parietes, the aperture may vary from a small peripheral opening to absence of a large part, or the whole, of the left dome; the contents will vary accordingly. In a large defect the thorax may house many of the abdominal viscera. *Contents varying with extent of aperture*

4. CLINICAL PICTURE

A hernia may be present without symptoms, and even when symptoms have appeared there may be remissions for days, weeks or months, as long as the passage of the contents of the alimentary canal is unimpeded. *Symptoms may be absent*

(1) Dyspepsia

Symptoms vary with the viscera *incarcerated*, but indigestion and flatulence are common to all cases, and there are few in which vomiting is absent. In the early days indigestion may differ little from that due to other causes, but soon characteristic features become recognizable and lead one to suspect their origin. *Characteristic features*

Pain tends to occur immediately after the ingestion of food; it is situated deep to the lower half or third of the sternum, often under the left costal margin, and it frequently extends through the chest to the back.



FIG. 249.—Elevated oesophagus. The cardia has been carried into the thorax.

separated by peritoneum and pleura only—through failure of the muscle elements to fuse at the areas already indicated—herniation may take place either during intra-uterine life or after birth, and a sac will be present. When hernia occurs as a result of infarction the serous membrane is usually destroyed and herniation will occur without a sac. When hernia is the result of a penetrating wound a sac is absent; a non-penetrating injury which weakens the diaphragm, however, may permit the development of a sac.

(c) The contents of the sac

In the oesophageal hiatus hernia a portion of the stomach first enters the sac and in many cases no other viscus is present. As the hiatus dilates and more of the stomach enters the thorax, the stomach, being more or less fixed at its extremities and along the lesser curvature, tends to rotate on its long axis, and in doing so the greater curvature draws a loop of colon up with it.



FIG. 250.—Arrow shows the lower end of the oesophagus carried up by the stomach.

Elevated oesophagus.—Sometimes in these cases the cardia is pushed up into the thorax carrying the lower end of the oesophagus with it, thus giving the appearance of a short oesophagus. The cardia may be able to move freely in and out of the abdomen with change of position (Fig. 249), but sometimes the stomach becomes

fixed in the thorax by adhesions. The patient, whose stomach is shown in Fig. 250, had a severe attack of obstruction on the last day of a sea voyage. Firm adhesions were found at operation. The skiagram was taken a year earlier, following less severe attacks.

In the pleuro-peritoneal type the contents are usually small and large intestine. If the posterior part of the left diaphragm is absent, stomach, colon and some small intestine are generally included. Frequently the spleen and the edge of the left lobe of the liver are drawn into the neck of the sac.

In retrosternal hernia part of the colon and often the terminal coil of the ileum are found (Fig. 251).

In hernia through the left dome any of the above-named viscera may be present depending upon the size of the defect (Fig. 247 (b)).

In hernia through the right dome, stomach alone has been found in this series.



FIG. 251.—Arrow shows termination of ileum; caecum and portion of colon in the thorax.

In herniation through a defect in the attachment of the diaphragm to the parietes, the aperture may vary from a small peripheral opening to absence of a large part, or the whole, of the left dome; the contents will vary accordingly. In a large defect the thorax may house many of the abdominal viscera. *Contents varying with extent of aperture*

4. CLINICAL PICTURE

A hernia may be present without symptoms, and even when symptoms have appeared there may be remissions for days, weeks or months, as long as the passage of the contents of the alimentary canal is unimpeded. *Symptoms may be absent*

(1) Dyspepsia

Symptoms vary with the viscera incarcerated, but indigestion and flatulence are common to all cases, and there are few in which vomiting is absent. In the early days indigestion may differ little from that due to other causes, but soon characteristic features become recognizable and lead one to suspect their origin. *Characteristic features*

Pain tends to occur immediately after the ingestion of food; it is situated deep to the lower half or third of the sternum, often under the left costal margin, and it frequently extends through the chest to the back.

Pain with food

Many patients feel as though they would burst. Their statements are often characteristic—"My symptoms are helped by limiting food—I can tell to a mouthful the limit of safety." "Pain only comes on with food; no food, no pain." Sometimes patients find that food can be taken without pain when standing up; in these cases the stomach probably slides out of the thorax in the erect position. In some patients pain is brought on by bending down as in gardening or cooking, the herniated portion of stomach being further compressed by this attitude.

Periodicity usually absent

Although there may be remissions during which dyspepsia ceases for a time, the periodicity observed in peptic ulceration rarely occurs with diaphragmatic hernia. There is never hunger pain, and relief does not follow the ingestion of food. Many patients have reduced food to a minimum because they are afraid to eat—"I look at food and I want it, but I do not eat it."

Occasionally a patient has no symptoms until sudden obstruction occurs, when there is severe pain and shock.

(2) Vomiting

Possible colonic obstruction

Vomiting may occur spontaneously, preceded by nausea, distension or pain. Often it gives immediate relief. Some patients induce vomiting because they have learned this; in others vomiting may continue for some days before relief is complete, and in this connexion it must be remembered that part of the colon may be contained in the sac, and may be obstructed to a greater or lesser extent. When such is the case, discomfort and vomiting are relieved only by evacuation of the contents of the incarcerated bowel, and this sometimes takes several days. Sometimes incarceration of the colon results in strangulation.

(3) Haematemesis and melaena

Obstruction of venous return flow

Haemorrhage was severe and frequent in 7 of the cases (14 per cent). In most of these it was the predominant feature. The haemoglobin has been known to fall to 20 per cent of normal. Bleeding is probably due to congestion, for although there is little interference with the arterial supply to the stomach, angulation of this organ over the margin of the defect in the diaphragm is sufficient to obstruct the venous return flow. Some surgeons believe that haemorrhage is due to shallow ulceration. Apart from one case, in which a deep chronic ulcer was present (Fig. 253), ulceration has not been demonstrated either by x-ray examination or at operation.

(4) Anaemia

Other causes

Secondary anaemia, without haematemesis or gross melaena, has been present in 11 of the 52 cases (22 per cent). It has frequently lasted for years, the haemoglobin content being raised by treatment, only to be followed by a recurrence of anaemia when treatment is stopped, since the real cause of the condition had not been recognized. One patient suffered severely for 14 years before an attack of pain led to x-ray examination and discovery of the hernia. Haematemesis, and anaemia without haematemesis, occur with similar frequency in cases of short oesophagus with partial thoracic stomach, and are caused by a similar mechanism.

(5) Dyspnoea

Attacks of breathlessness and faintness are sometimes severe and frightening to the patient. A severe attack may occur only at intervals of months or years. Fifteen out of 52 patients (30 per cent) complained of this symptom, which is caused by pressure upon the pericardium and the heart by a sudden increase in distension. This sudden increase may be occasioned by movement or posture. In big hernias the left lung is crowded into the upper part of the thorax, and the mediastinum, with the heart, is displaced to the right. It is believed by some observers that the attacks of faintness are due to pressure upon the lung, but in most cases increase in size of the hernia occurs slowly, and the patients adjust their activities accordingly.

(6) Cough and "asthma"

Four patients (8 per cent) have suffered from uncontrollable spasms of coughing on taking food when sitting at table. They all called the attacks "asthma". They had learned that this could be avoided by taking their meals standing. The reason for this freedom is that the stomach can slide out of the thorax in the erect position, whereas it is clear that the sitting posture tends to compress the abdomen, thus forcing more of its contents—increased during the meal—into the thoracic loculus, and inducing an uncontrollable attack of coughing. *Posture*



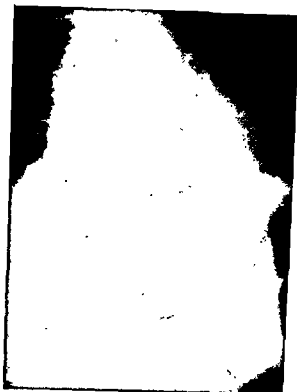
FIG. 252.—Colon shown in right thorax. Arrow shows defect in diaphragm.

(7) Loss of weight

Fifteen patients (30 per cent) have lost weight, for their suffering from taking food has been greater than that due to the deprivation of it. Some patients are stout—possibly that is their natural habit; possibly almost unconsciously they are more comfortable when avoiding unnecessary activities.

(8) Obstruction

Practically all the symptoms are produced by obstruction, mild or severe, of the portion of the alimentary canal involved in the hernia. The lumen contains gas or food, and any increase in the contents may angulate the viscus more acutely over the margin of the defect in the diaphragm. The contents may eventually pass on, with relief of symptoms, but in some cases strangulation of the stomach occurs (8 per cent of my cases) and the patient becomes desperately ill and may die as the direct result of this complication. Very severe—but not fatal—obstruction of the colon occurred in one case (Fig. 252). Evarts *Angulation of the viscus over margin of defect*



(*a*)



(*b*)

Fig. 253.—*Chronic ulcer. (a) Patient erect; (b)* patient supine (part of the ulcer above the diaphragm).

Graham (1947) *has informed* me that he has seen 7 cases of obstruction of the colon admitted to the Barnes Hospital, St. Louis, *too late for operation.*

(9) Adventitious sounds in the thorax

Cardiac and intestinal sounds

These *sounds* depend upon the size and situation of the hernia. When of moderate size abnormal sounds may not be detected, but in a *large left-sided hernia when the mediastinum* is displaced to the right, heart sounds may be medial to the right nipple and *borborygmi are heard in the left* side of the chest. In eventration or congenital absence of part of the diaphragm, *intestinal* sounds may be *heard* widely over the thorax.

(10) Associated conditions

Gall-stones have been found at operation in 8 cases (16 per cent): peptic ulcer has been demonstrated by x-ray examination before *operation in 1* case (2 per cent). In this patient a deep chronic ulcer on the lesser curvature of the stomach *was situated above* the diaphragm with the patient supine, but when he was erect the stomach with the ulcer *slid into the abdomen (Fig. 253 (a)* and (b)). This patient also had a pharyngeal diverticulum. One patient had been operated upon for carcinoma of the breast and for haemorrhoids, both of which had recurred. *She had diverticulitis with* attacks of subacute obstruction and a severe degree of scoliosis. With these associated

conditions it was not easy to apportion the relative amount of discomfort due to each and operation was certainly contra-indicated.

5. DIAGNOSIS

The indigestion, flatulence and vomiting of diaphragmatic hernia are commonly regarded in the first instance as due to peptic ulcer, gall-stones or appendicitis. When haematemesis, melaena or anaemia is present the suspicion of gastric ulcer is strengthened. In the latter condition, however, the pain has, or had at some period, the well-recognized periodicity and is usually situated in the epigastrium; with a hernia involving the stomach, on the other hand, pain is bursting in character, is prone to follow immediately upon the intake of food, is most likely to be situated deep to the sternum, frequently extends through to the back, and may be affected by alterations in posture, especially by bending.

The sudden relief of pain which sometimes occurs is not dissimilar to the relief which may follow gall-stone colic and the picture is complicated by the actual presence of gall-stones in a considerable proportion of patients with hernia.

The substernal situation

Possible misdiagnosis



(a)



(b)

FIG. 254.—(a) Stomach in right thorax with torsion and complete obstruction at the time of operation; (b) loop of colon in same sac with the stomach.

of the pain has led to the diagnosis of angina pectoris. Naturally the presence of hernia does not preclude the possibility of coronary disease. This diagnostic problem was met with in one case of hernia, for the patient suffered intensely, immediately after every meal, from substernal pain which disappeared suddenly about half an hour later. There was evidence of myocardial disease and the patient has since died from coronary thrombosis.

Persistent secondary anaemia should always lead to x-ray examination of the stomach. This will reveal an abnormality but there is still the problem of differentiating between a short oesophagus with part of the stomach in the thorax, and a diaphragmatic hernia with the oesophagus of full length. To distinguish between the two is sometimes by no means easy, and calls for special skill and experience in radiographic technique and interpretation. In some cases of short oesophagus with partial thoracic stomach, more and more of the stomach becomes drawn and pushed into the thorax, and with rotation of the stomach a portion of the colon and of the great omentum is drawn up with it (Fig. 254 (a) and (b)). Pain due to sudden obstruction of the colon can be distinguished from that resulting from obstruction due to other causes only by special methods of investigation.

Short oesophagus

6. PROGNOSIS

A diaphragmatic hernia may be present for a long time without severe symptoms as long as the contents of the sac are able to slide in and out of the thorax, or unless obstruction occurs. Once herniation has begun, however, constantly recurring positive pressure in the abdomen and negative pressure in the thorax in the course of the respiratory cycle lead almost inevitably to increase in the size of the hernia and to complications. Thus, owing to fixation at the cardiac and pyloric ends of the stomach, the greater curvature rotates cranially, drawing with it the attached transverse colon and great omentum. Attacks of congestion, obstruction and even strangulation occur. Following these, adhesions form in the vicinity of the neck of the sac which limit or prevent mobility and onward passage of the contents. Obstruction of the stomach has occurred several times in this series manifesting itself clinically by the severity of the attacks of pain and vomiting and by dehydration, and at operation by recent as well as old adhesions, localized oedema and strangulation. In one case sent by a practitioner who considered the patient fit to travel to hospital, strangulation had caused such severe shock that attempts at resuscitation failed, the patient dying a few hours after arrival. The post-mortem examination revealed strangulation of the stomach with areas of gangrene. Incarceration of a herniated loop of colon can cause obstruction with severe shock and even death.

Obstructed hernia

Strangulation

Apart from the complications affecting the contents of the sac, the pressure effects of the hernia upon the mediastinum and pericardium must be borne in mind; these will naturally become more embarrassing as the hernia increases in size.

Pressure upon mediastinum and heart

7. TREATMENT

A. Palliative

Many patients have learned from experience what induces an attack of pain, and to some extent how to prevent it. Some remain comparatively free

when the amount of food taken at one time is strictly limited. Some can avoid the discomfort of a meal only when standing; others who limit themselves to the simplest food find that they still get pain but obtain relief by vomiting.

It may happen that distressing attacks of vomiting produce only small quantities of fluid. Passage of a Ryle's tube may give relief, but by the time this occurs some degree of obstruction is to be suspected, and unless relief is given the condition becomes dangerous. Some patients who suffer from uncontrollable coughing on going to bed find relief from lying on one side or the other, usually the left. Such palliative measures may be required temporarily, while a patient is being prepared for operation, or permanently if operation is contra-indicated, for some patients are very old when first seen and may already suffer from complications such as chronic bronchitis or cardiovascular disease severe enough to constitute an absolute contra-indication to surgery. *Temporary relief by passage of a Ryle's tube*

B. Radical

(1) Preliminary considerations

Hernia is found with increasing frequency in infants. So long as the patient can be guided safely it is wise to postpone operation as long as possible for obvious reasons, but in nearly every case the symptoms have become so distressing that operation has become imperative. Sometimes indeed, with the patient under observation in hospital, operation has had to be performed as an emergency at night when it might have been planned more wisely, without haste, between attacks. An emergency operation on an infant for this condition greatly increases the risk. Neither infancy nor old age in themselves contra-indicate operation, although the margin of safety is narrower. The youngest patient operated upon was aged 11 weeks; the oldest was a woman of 75 years; the latter also suffered from auricular fibrillation. The operation was performed in 1936—she remains free from symptoms.

As before any other serious operation, the preliminary medical treatment must be thorough, and any associated disorder, especially of the lungs or heart, must be given appropriate treatment. If the patient is anaemic through haemorrhage, blood transfusion must be employed to restore the haemoglobin to an adequate level. Transfusion is not necessary as a routine measure. If the patient is dehydrated by uncontrollable vomiting and cannot retain fluids, intravenous glucose solution must be given. *Pre-operative preparation*

When the transthoracic approach is to be used, preliminary collapse of the lung has been advocated. This has been carried out in about one-third of the operation cases in this series. Patients who have not had the lung collapsed have not suffered any disability on this account, and their operation and post-operative course have been just as smooth as when the lung has been collapsed beforehand. *Transthoracic approach*

(2) Anaesthesia

The endotracheal method has given smoothness and safety. This is scarcely obtainable in any other way. If the transthoracic approach has been employed the lung is expanded by positive pressure as the chest incision is closed. *Endotracheal method*

C. Approach

Most surgeons consider that the approach to the diaphragm through the thorax is easier and more direct than that by the abdomen. For hiatus hernias,

hernias through a dome, pleuro-peritoneal defects and the wider defects in this region, the transthoracic approach gives adequate access. Stuart Harrington, whose work all surgeons respect and admire, prefers the abdominal approach in most cases.

(1) Thoracic approach

(i) *Para-oesophageal hernia.*—After anaesthesia has been induced the patient is placed in the right lateral position, the lower part of the thorax being raised and efficiently fixed. An incision is made along the eighth rib, and this rib is resected from the cartilage in front to the angle behind. If this does not give adequate access a quarter of an inch of the seventh or ninth rib is resected anterior to the angle. On incising the pleura the hernia is seen bulging behind the pulmonary ligament. The insertion of a rib-spreader gives adequate access. Stomach is usually felt occupying the sac. At this stage the left phrenic nerve may be defined and crushed with a haemostat, rendering the left dome flaccid. This facilitates manipulations but it leaves the patient with a paralysed and raised dome for some months, and if the operation can be completed without crushing—as it often can be—the nerve may be left intact. The overlying pleura is incised and reflected. The oesophagus is defined as it approaches and enters the stomach. The sac is then opened. The hernia is almost always of the sliding type, the proximal part of the lesser curvature being attached to the neighbouring wall of the sac by five or six small vessels lying in line and drawn up with it. The greater part of the herniated stomach is usually reduced readily, but unless the attached area is separated from the sac, the vessels ligated and the sac completely removed, the hernia will recur. In some cases the hernia is irreducible because of adhesions between the stomach and the neck of the sac, and in some the sac contains omentum and fluid. When fluid is present it is due to congestion in an irreducible hernia. Generally the adhesions can be separated from the thoracic side, but when dense it has occasionally been found safer to incise the diaphragm an inch or two to the left of the hiatus and continue this incision into the hiatus. This gives better access to the adhesions. When the vessels have been ligated a small area of stomach wall—the attached area—is left bare of peritoneum. At this stage the anaesthetist should pass a full-size oesophageal tube. The margins of the dilated hiatus are overlapped by mattress sutures first, and then the upper leaf is sutured to the lower with interrupted stitches; the medial sutures pick up the oesophageal wall, care being taken to ensure that the sutures are not drawn so tightly as to necrose the enclosed tissues or cut out. When the diaphragm has been incised this will be closed in continuity with the hiatus. The opening in the pleura over the hernial site and lower oesophagus is closed. The area is left clean and dry. The chest wall is closed in layers, the anaesthetist inducing positive pressure in the lungs as the final closure is made. The dressings are held in place by Elastoplast which also splints the chest wall.

Sliding type of hernia

Steps to avoid recurrence

(ii) *Pleuro-peritoneal "canal" hernia.*—The high—and early—mortality in this type of hernia has already been indicated. For patients who survive, the margins are overlapped by mattress sutures and the overlap is stitched down.

(iii) *Congenital absence of muscle in the posterior part of the left diaphragm with resulting hernia.*—The defect is always large. In these cases the phrenic nerve is crushed, for the diaphragm must be flaccid to help to bridge the gap.

Phrenic nerve crushed

The contents of the sac may almost fill the left thorax, and in order to reduce them and retain them in the abdomen while the defect is being closed, it may be necessary to make an abdominal incision to enable an assistant to hold the herniated viscera below the level of the diaphragm while repair is carried out. The peritoneum constituting the posterior leaf of the sac, together with such areolar and fibrous tissue as can be found, is poor material with which to close the defect. Operation upon this type is improved by the use of fascial sutures to attach the anterior margin of the defect to the chest wall, the sutures encircling the appropriate rib. Rib resection may be advisable to allow the diaphragm

Use of fascial sutures

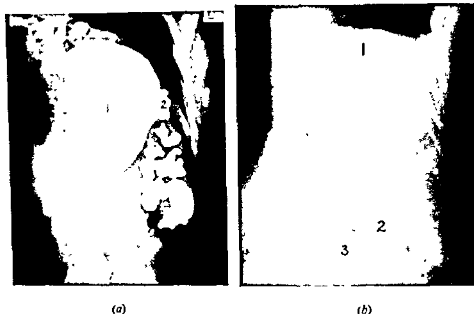


FIG. 255.—(*a*) Before operation. The fundus of the stomach: (1) seen almost reaching the sternoclavicular articulation; (2) colon. (*b*) After operation: (1) fundus of stomach below diaphragm; (2) pre-pyloric segment; (3) duodenal cap.

to reach the chest wall. In spite of the difficulties patients have been cured of their symptoms. Illustrating one case, Fig. 255 (a) and (b) shows the stomach almost reaching the sternoclavicular articulation before operation, and below the diaphragm afterwards. The patient remained well until her death many years later. Another patient operated upon in 1927 gave a dinner to the nursing staff on each anniversary of her operation until the war made it impossible; in 1945 she was still well.

(iv) *Retrosternal hernia.*—This hernia is situated in the right thorax, and a sac is present. The contents are colon, perhaps with the caecum, ascending colon and a length of ileum. Sometimes these are free from adhesions and are withdrawn easily; sometimes the coils are adherent to one another and to the sac. The approach is through a vertical epigastric incision. In my first case with the contents of the sac high in the thorax (Fig. 251) the incision was continued upwards over the lower third of the sternum, and this structure divided longitudinally and transversely. Later I have found that the contents of the sac can be withdrawn without this procedure. Even when adhesions are

Vertical epigastric incision

universal the sac, being lightly attached by areolar tissue to the pleura, can be dissected free as the hernia and sac are reduced *en masse*, the separation of the coils from one another and from the sac being carried out after reduction.

Closure of the defect is usually easy in the posterior half; as the sternum is approached the margins are separated more widely, and fascial sutures may be necessary to close the anterior half of the gap. Sometimes the margins of the defect can be sutured to the posterior sheath of the rectus abdominis muscle.

Difficulties encountered

(v) *Through the left dome.*—Several difficulties are encountered in this type. A sac is not present and the herniated viscera may fill the left thorax. The stomach may be adherent to the base of the lung which is crowded into the apex of the chest, and the herniated viscera are adherent to the margins of the defect. The stomach is prone to be very distended (Fig. 247 (b) and (c)). It is obvious that preliminary pneumothorax should never be carried out in cases of this kind, for the lung is already compressed, and the mediastinum, with the heart, is displaced to the right. The approach is through the thorax. After opening the thorax I have found it wise to deflate the stomach by means of a trocar with tube attached—for it has filled the thoracic cavity and the abdomen has become unaccustomed to housing it—and then to suture the puncture. The necessary manipulations are more easily carried out with the stomach deflated. Adhesions of stomach to base of lung are separated, and then adhesions to the margins of the defect. Even then it has been impossible to return the stomach to the abdominal cavity until an abdominal incision has been made through which an assistant has gently withdrawn the stomach as it was fed into and through the defect. The margins of the defect are overlapped by mattress sutures, and the upper leaf again sutured to the lower. With a greatly distended stomach there still remains the problem of housing it in the abdomen. I have performed a gastrostomy at the site of the deflation puncture in order to give exit to stomach gas until this organ regains its tone and normal size. The necessity for this procedure will depend upon the degree of distension of the stomach and the length of time it has been housed in the thorax.

Approach through thorax

Possible gastrostomy

(vi) *Through the right dome.*—The approach is through the right thorax. A sac is present in these cases. Repair is effected by overlapping (Fig. 248 (a) and (b)).

(2) Abdominal approach

If it is desirable to paralyse the left dome the phrenic nerve will be crushed in the neck. The abdominal incision is made through the left rectus, from the ensiform cartilage above downwards and outwards. It is necessary to divide the suspensory (coronary) ligament of the left lobe of the liver, and this lobe is retracted from the field of operation by means of a broad deep retractor. The contents of the sac are withdrawn, the sac itself completely cut away—remembering the area of stomach which is attached to the sac—and the defect in the diaphragm dealt with as found necessary by mattress sutures first and then by suturing the overlapping to the subjacent leaf.

Some surgeons prefer the thoracic, others the abdominal, approach. There may be complications in either or both cavities. When the spleen is adherent to the margins of the defect it is safer to dissect it free from below; the gall-bladder and stomach can be explored from the abdomen. I have found adhesions of the stomach to the base of the lung, which had been pushed into

the upper part of the thorax, and not infrequently very dense adhesions around, and well above the neck of the sac, which I think could have been dealt with only from the thorax (Fig. 256). When the necessity has seemed to demand it I have, as already indicated, opened both cavities.

D. Traumatic Hernia

The injury may have seemed trivial at the time of its occurrence, any symptoms being attributed to shock; on these symptoms gradually disappearing, the possibility of more definite injury has, perhaps, been ignored. Later, discomfort or breathlessness may lead to investigation and to the discovery, as a result, of a hernia. Such a hernia was found in a young man years after a motor accident in France. A missile or a bayonet not only makes a rent in the diaphragm, but tears through adjoining viscera. Haemorrhage, or other damage, may necessitate early intervention, and operation will follow the lines of surgical practice. In a small hernia, due to trauma, the viscera may be comparatively easily freed from adhesions, returned to the abdomen, and the defect closed by overlapping the margins. In severe injuries an abdomino-thoracic approach may facilitate access to the structures involved.

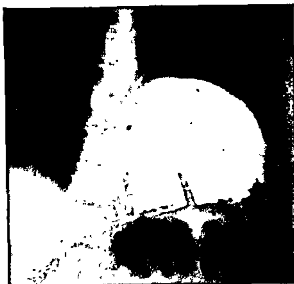


Fig. 256.—Stomach with greater curvature uppermost; pylorus fixed above diaphragm; barium leaving pylorus in a thin trickle.

E. After-treatment

In all cases, deep breathing should be practised several times a day and movement encouraged within reason. If the temperature remains raised an x-ray examination should be made, for fluid occasionally appears. This is usually small in amount and I have rarely felt it necessary to aspirate as it disappears spontaneously. In two patients from whom fluid was withdrawn a small amount again appeared. This cleared up completely with breathing exercises. In two cases I dusted a sulphonamide over the line of suture, but as no case has become infected I doubt the necessity for this. *Deep breathing*

F. Mortality

Of the adults, 3 patients have died as the result of operation. In the first (a defect in the foramen of Bochdalek) the cause was a pulmonary embolus. The patient was perfectly well for 10 days. She was sitting up in bed enjoying her lunch and talking to her nurse when she suddenly became distressed, and died *Pulmonary embolus*

in a few minutes. In the second case (hiatus hernia) breathing was embarrassed on regaining consciousness. It is thought that the pleura and lung surface had been injured, with formation of a valvular opening and increasing

Pneumothorax

pneumothorax. This was in 1932. The condition would now be recognized and relieved by aspirating the thorax. In the third case, most of the stomach including the pylorus and first part of the duodenum was situated well above the diaphragm and was fixed there by dense adhesions (Fig. 256). This patient had suffered severely for 30 years. Separation of the adhesions and reduction of the hernia was a lengthy proceeding. The operation was completed satisfactorily but some collapse of the lower lobe of the right (opposite) side followed, with slight irregular temperature. For the first time in this long history food was taken without any discomfort, but a lung abscess slowly formed and a month later the patient died.

Lung abscess

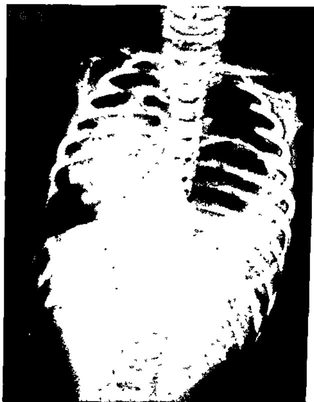


Fig. 257.—Showing a large herniation of intestines into the left thorax with the mediastinum and heart shifted far to the right.

Assessment of risk in operating on infants

In infants, delay has too often been to the detriment of the patient. Naturally this does not imply that infants may be operated upon without risk, for it has already been stated that some congenital hernias are incompatible with life; some are so extensive and the infant so young and frail that operation cannot be undertaken with reasonable hope of success. But when an infant has survived some months, or years, and it is recognized that attacks of pain or distress are continuing, *operation should be* planned and carried out. It may be found that anatomical defects are so extensive that satisfactory repair is very difficult. One child had lived for 2 years and 3 months with increasing distress. X-ray examination had shown a large herniation of intestines into the left thorax with the mediastinum and heart shifted far to the right (Fig. 257). At operation a large sac was found which contained about half the herniated viscera; the other half had passed through an opening in the sac and were lying free in the thoracic cavity. In an infant of 11 weeks it had been thought that the operation could be postponed until he became a little older. An acute obstruction in the night, however, necessitated an emergency operation. A satisfactory repair was carried

out without difficulty, but the acute attack had sapped the infant's strength and the operation was too much. Of 5 children operated upon there were 2 deaths.

Special studies of hernia in children have been made by Stephens (1935) and Donovan (1945).

Of the 52 patients seen, 32 were operated upon. Of these 27 were adults and 5 were children.

REFERENCES

Donovan, E. J. (1945). *Ann. Surg.*, 122, 569.
Dunhill, T. P. (1935). *Brit. J. Surg.*, 22, 475.
Graham, Evarts (1947). Personal communication.
Harrington, S. W. (1945). *Ann. Surg.*, 122, 546.
Hume, J. B. (1922). *Brit. J. Surg.*, 10, 207.
— (1932). *Ibid.*, 19, 527.
Keith, A. (1910). *Brit. med. J.*, 2, 1297.
— (1924). *Brit. J. Surg.*, 11, 455.
Kirk, J. (1948). Personal communication.
Stephens, H. D. (1935). *Aust. N. Z. J. Surg.*, 5, 161.
[References to other titles are given under Hernia—Diaphragmatic in the Index Volume. The subject of Diaphragmatic Hernia is also dealt with under the heading of Hernia in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 470.]

in a few minutes. In the second case (hiatus hernia) breathing was embarrassed on regaining consciousness. It is thought that the pleura and lung surface had been injured, with formation of a valvular opening and increasing

Pneumothorax

pneumothorax. This was in 1932. The condition would now be recognized and relieved by aspirating the thorax. In the third case, most of the stomach including the pylorus and first part of the duodenum was situated well above the diaphragm and was fixed there by dense adhesions (Fig. 256). This patient had suffered severely for 30 years. Separation of the adhesions and reduction of the hernia was a lengthy proceeding. The operation was completed satisfactorily but some collapse of the lower lobe of the right (opposite) side followed, with slight irregular temperature. For the first time in this long history food was taken without any discomfort,

Lung abscess

but a lung abscess slowly formed and a month later the patient died.

Assessment of risk in operating on infants

In infants, delay has too often been to the detriment of the patient. Naturally this does not imply that infants may be operated upon without risk, for it has already been stated that some congenital hernias are incompatible with life; some are so extensive and the infant so young and frail that operation cannot be undertaken with reasonable hope of success. But when an infant has survived some months, or years, and it is recognized that attacks of pain or distress are continuing, operation should be planned and carried out. It may be found that anatomical defects are so extensive that satisfactory repair is very difficult. One child had lived for 2 years and 3 months with increasing distress. X-ray examination had shown a large herniation of intestines into the left thorax with the mediastinum and heart shifted far to the right (Fig. 257). At operation a large sac was found which contained about half the herniated viscera; the other half had passed through an opening in the sac and were lying free in the thoracic cavity. In an infant of 11 weeks it had been thought that the operation could be postponed until he became a little older. An acute obstruction in the night, however, necessitated an emergency operation. A satisfactory repair was carried

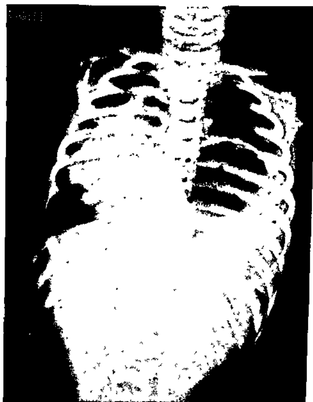


FIG. 257.—Showing a large herniation of intestines into the left thorax with the mediastinum and heart shifted far to the right.

although no known common aetiological factor has, as yet, been convincingly demonstrated.

3. CLINICAL PICTURE

(1) Acute stage

A short period of malaise usually precedes the onset of the process, which demonstrates its presence by pain; the pain is usually localized to the area of one or of several adjacent dermatomes. At a variable period of time, which seldom exceeds forty-eight hours, pain is followed, or occasionally may be preceded, by a crop of vesicles which usually make their earliest appearance on the dorsal surface of the body. The original crop is succeeded by two or three others so that eventually the whole area of the dermatome may be covered by them. The vesicles are shotty to touch, do not readily rupture and they are present against an inflamed background; at first the vesicles contain clear fluid, but this rapidly becomes opaque and, if secondarily infected, purulent. Secondary infections are common with herpes occurring in the distribution of the trigeminal nerve. As the rash appears, the pain—which may be excruciating—recedes, though in some cases it may continue for weeks in a severe form. As a week or more passes, the vesicles dry up and eventually the scab separates, leaving a pitted scar. In the literature, cases are recounted in which the radicular-like pain alone has occurred, without a subsequent herpetiform rash; the extreme difficulty in making the correct diagnosis in the absence of the characteristic rash is apparent. It is also not uncommon to find cases in which there is an associated, but transient, weakness of one of the muscles supplied by the anterior portion of the root, the ganglion of which is involved; the paralysis is partial and practically never persists. The accepted explanation is that the infection of the ganglion has been so severe and so extensive as to cause pressure on the anterior root.

Secondary infections

Herpes zoster affecting the ophthalmic division of the fifth cranial nerve must be regarded as a serious condition, for it may be associated with the eruption of vesicles on the cornea; these tend to leave an opacity on the cornea which impairs vision; if the vesicles become grossly infected a panophthalmitis may result, necessitating removal of the globe. Scarring is more severe on the forehead than it is elsewhere. With involvement of the geniculate ganglion there is an associated, but transient, facial palsy and not infrequently a crop of vesicles in the region of the external auditory meatus—a syndrome described by Ramsay Hunt; there is no clear evidence that the facial nerve has a cutaneous sensory component, and the vesicles in the ears are more probably associated with infection in one of the cervical ganglia.

Corneal opacity

During the acute stage, and especially if there is secondary infection, the glands in the neighbourhood are enlarged and tender.

Sensory examination reveals at first a hyperalgesia, followed by a hypoalgesia the presence of which may be indicated by a lowered threshold with an over-reaction to painful stimuli. Slight anaesthesia may also be found. In a few cases a pleocytosis, mainly of lymphocytes, occurs in the cerebrospinal fluid.

(2) Chronic stage

Subsequent to the acute stage there is a prolonged chronic stage in which the patient may complain of disturbing subjective sensations, which vary from a

Subjective symptoms

HERPES ZOSTER

By E. A. CARMICHAEL, C.B.E., F.R.C.P.
Physician, Out-patient Department, National Hospital, London;
Director of Neurological Research Unit, Medical Research Council

1. DEFINITION

182.] The name zoster means a girdle; it was first used to describe a form of herpes which spreads from the back and round the chest. Shingles, a term derived from *cingulum*, has a similar meaning. It is to be remembered, however, that the disease process may affect any sensory root ganglion and that, therefore, the herpetiform rash may be encountered on the limbs as well as on the body.

2. AETIOLOGY AND PATHOLOGY

Herpes zoster is an inflammatory disease which has its main locus in the posterior root ganglia or in the sensory ganglia of the cranial nerves—such as the Gasserian or the geniculate ganglion. The changes visible on histological examination are a very acute inflammation of the ganglion, a heavy round-celled infiltration and, frequently, destruction of ganglion cells; small haemorrhages are often present. The reaction of the ganglion cell resembles those reactions found with virus infections, though no definite inclusion bodies have, as yet, been demonstrated. The neurones peripheral to the ganglion cells may be in a stage of degeneration, this being dependent upon the age of the lesion. On section the vesicles are found to be multilocular; around them there is an increase in vascularity and some cellular exudate. Commonly, several ganglia are affected, with one ganglion showing greater inflammation than that present in neighbouring ganglia. The central nervous system is unaffected, except in the very unusual case in which there is an associated encephalitis.

Associated diseases

Sometimes the process is associated with other diseases affecting the posterior roots, for example, with metastatic tumour or vertebral injury. There is no clear indication that such processes are the direct causes of herpes, and they may only lower the local resistance. Herpes has been reported as occurring during the administration of the arsenicals in syphilis; it is controversial whether such administration is the cause of the herpes.

It is now generally accepted that the disease is the result of a virus infection which has a predilection for the posterior root ganglia, similar to the affinity which the poliomyelitis virus has for the anterior horn cells in the spinal cord and medulla: there is no relationship between the two infections.

Relationship to varicella

The relationship of herpes zoster to varicella, however, has received much attention,

HETEROTOPIA

By A. L. TAYLOR, M.D.
Pathologist, Bristol Royal Hospital; Lecturer in Clinical Pathology, University of Bristol

1. DEFINITION AND AETIOLOGY

183.] Heterotopia may be briefly defined as misplacement of tissue. Whenever a tissue of organized adult structure appears in a situation to which it does not normally belong, the condition is one of heterotopia. Heterotopia is confined, with few exceptions, to the epithelial structures of the body, a fact which is undoubtedly related to the remarkable capacity of the embryonic ectoderm and entoderm—particularly the latter—for wide and purposive differentiation.

When, owing to some error of development, abnormal differentiation takes place in the primitive cells of the embryo, a congenital heterotopia results; when, as a result of local inflammatory or destructive processes, epithelium appears in an abnormal site, then the heterotopia is of an acquired type. *Congenital heterotopia* *Acquired heterotopia*

Heterotopia thus falls naturally into two groups, congenital and acquired; the latter group, although of considerable academic interest—especially in relation to the problem of malignant disease—is unimportant to the surgeon and need be discussed only briefly. Congenital heterotopia, on the other hand, gives rise to a number of lesions which are encountered from time to time in surgical practice; although admittedly many examples are found unexpectedly at necropsy and appear to have been symptomless during life, others may be responsible for serious and even fatal complications.

2. CONGENITAL HETEROTOPIA

(1) Heterotopia of ectodermal origin

These heterotopias usually take the form of cystic tumours, developing over the sites of closure of the embryonic clefts and fissures. *Site of development*

(a) Dermoid cysts

The commonest example is the dermoid cyst, usually occurring at the angles of the orbit or in the midline of the neck but sometimes found in the sacral

steady pain to a tingling and burning sensation. The discomfort caused by these abnormal sensations is usually sufficient to cause loss of sleep which, if prolonged, leads to marked disability.

4. TREATMENT

During the acute stage bland protective measures are indicated, such as dusting with a powder containing starch or zinc oxide; a collodion dressing may be useful. The administration of anti-neuralgics is required, and in very severe cases morphine may be necessary. If the cornea is involved, special measures are necessary in order to keep the conjunctival sac clean.

Posterior rhizotomy

Section of spino-thalamic tract

In cases in which the pain persists, surgical intervention has to be considered; posterior rhizotomy provides relief in a limited number of cases in which there is persistent pain, if the operation is carried out shortly after the acute stage. Section of the spino-thalamic tract has been shown to bring relief in other cases. Both operations, however, may provide little or no relief of the disturbing sensation, and this fact has given rise to the suggestion that in herpes zoster there is involvement of the central nervous system. For the unpleasant subjective sensation in the distribution of the first division of the fifth cranial nerve, very radical surgical measures have been evolved; it is, however, only in the most resistant cases that surgical measures should be contemplated. There is no doubt that the great majority of patients recover completely and it is only in a few that post-herpetic neuralgia ensues.

Post-herpetic neuralgia

Patients in the latter category recover gradually in the process of years, making the proper assessment of surgical intervention exceedingly difficult.

[References to other titles are given under Herpes Zoster in the Index Volume. The subject is also dealt with in the *British Encyclopaedia of Medical Practice* (1937), Vol. 6, p. 513.]

wall. The glands are sometimes bilateral and are then situated at slightly different levels. In appearance they resemble small erosions or shallow ulcers, and may be mistaken for them on oesophagoscopy. Microscopically, however, there is no sign of ulceration; they reproduce faithfully the structure of normal adult fundal mucosa complete with parietal cells, and there can be no doubt that they secrete gastric juice. These heterotopias occasion no symptoms during life and are revealed only in the course of routine necropsies; malignant change in them is unknown.

(ii) *Stomach*.—In the stomach superficial heterotopia of intestinal-gland type is relatively frequent, occurring in all parts of the mucosa. Usually of only microscopic extent, these aberrant islets consist of well-formed villi and crypts of Lieberkühn showing an abrupt transition to normal gastric glands on either side. Microscopically no present or past inflammatory lesion is evident in these heterotopic islets, which one must conclude have been developed *pari passu* with the normal epithelium of the part. Their clinical significance is doubtful, but on comparative grounds it is not impossible that they may furnish a site of election for acute gastric ulcer. *Intestinal-gland type*

Much more rarely aberrant glands of duodenal (Brunner) type are found; in the few reported cases it appears that ulceration occurring in heterotopic duodenal mucosa tends to pursue an unusually rapid course, with early perforation. *Duodenal-gland type*



FIG. 258.—Polyp consisting mainly of aberrant pancreatic tissue situated at the tip of a Meckel's diverticulum. The diverticulum has become inverted to form the apex of an intussusception, causing intestinal obstruction in a girl of 3 years.

(iii) *Duodenum and small intestine*.—In the duodenum and small intestine gastric-gland heterotopia is rare except in relation to Meckel's diverticulum. This condition results from imperfect closure of the vitelline duct and it is noteworthy that in the embryo, at the time when physiological separation takes place, this duct possesses an epithelial lining which has the same developmental potentialities as has the intestinal entoderm itself. Here it is not surprising, therefore, to find abnormal epithelial differentiation resulting in heterotopia. About 25 per cent of diverticula show this anomaly, which is almost invariably of gastric-gland type; the aberrant epithelium may line the tip, or even the whole of the diverticulum (Fig. 258). At this site the heterotopia is a not uncommon cause of peptic ulcer, an important condition which, if neglected, may lead eventually to perforation and generalized peritonitis. It is significant that when ulceration *A possible cause of peptic ulcer*

region and elsewhere. All such cysts possess a squamous epithelial lining with hair follicles, sebaceous glands and sweat glands; the gradual enlargement of the cysts is due to a steady accumulation of hair and sebaceous secretion.

(*b*) *Branchial cysts*

These cysts arise from imperfect closure of the cervical sinus and form tumours which are situated laterally beneath the angle of the jaw. They are lined by stratified squamous or columnar epithelium and their contents are fluid or at most glairy, since no sebaceous glands or hair follicles are present; an invariable accompaniment is a sheath of lymphoid tissue surrounding the cyst wall.

(*c*) *Thyroglossal cysts*

Thyroglossal cysts are derived from persistent remnants of the thyroglossal tract and form midline tumours at the base of the tongue or in the neck; these remnants may be cystic, lined by columnar epithelium, or solid, being then composed of adult thyroid tissue.

Benign, non-neoplastic lesions

The foregoing heterotopic conditions are common examples of congenital malformation, although they rarely make their appearance before puberty; all are benign non-neoplastic lesions and present little difficulty in diagnosis and treatment.

(2) Heterotopia of entodermal origin

Superficial and deep heterotopia

The entoderm of the primitive digestive tube is destined to give rise to a great variety of epithelial structures of widely differing function, all of which arise from embryonal cells which are morphologically identical. Heterotopia is the result of some slight error of development whereby, in restricted areas, cell-differentiation pursues an abnormal course. The aberrant epithelium thus produced may be confined strictly to the mucous membrane (superficial heterotopia) or by further growth may penetrate the muscularis mucosae which forms its deep boundary (deep heterotopia); in the latter case, tumour-like formations may result, the great majority of which consist wholly or in part of pancreatic tissue.

Mechanism of production

The congenital heterotopias are confined almost without exception to the upper portion of the intestinal tract—that portion developed from the primitive fore-gut. The precise mechanism of their production is still conjectural, but as Nicholson (1922) insists, they are readily explained as malformations occurring in the entoderm of the individual, that is, they are dysontogenetic and not atavistic phenomena. It should be noted that many examples are associated with congenital diverticula, and one may reasonably suppose that they similarly take origin in diverticula of the foetal entoderm; such diverticula constantly occur (Lewis and Thyng, 1908) in early mammalian embryos, in which they are limited to the anti-mesenteric wall of the fore-gut and so correspond well in their distribution to aberrant pancreas and its allied conditions.

(*a*) *Superficial*

"Upper cardiac glands"

(i) *Oesophagus*.—In the oesophagus superficial congenital heterotopia takes the form of small elongated patches of aberrant gastric mucosa, the "upper cardiac glands", situated in the post-cricoid region, usually on the posterior

symptomless and devoid of clinical interest, but occasionally a heterotopic nodule has been found in an inverted Meckel's diverticulum, there forming the apex of an intussusception (Fig. 260).

(ii) *Adenomyoma of the stomach.*—This condition merits special consideration because, although genetically closely related to accessory pancreas, it shows a great diversity of structure with evidence of tumour-like overgrowth; moreover, it is capable of causing gastric symptoms.

Adenomyoma presents itself as a localized but ill-defined swelling in the pyloric region of the stomach. The mucous membrane and peritoneal coat are intact, and the heterotopic tissues are confined to the musculature, which shows a characteristic thickening with whorling; on section the cut surface is seen to be studded with tiny cysts and solid yellowish areas contrasting with the darker muscular background.



FIG. 260.—Heterotopic gastric mucosa lining the distal end of a Meckel's diverticulum. A nodule of redundant fibrous tissue occupying the tip is covered by a thick mucous membrane of gastric (fundal) type, rich in secretory parietal cells. When peptic ulceration occurs it does so in the adjoining intestinal epithelium (× 4).



FIG. 261.—Adenomyoma of pylorus. Photomicrograph showing three main types of heterotopic epithelium: Brunner type glands (above), undifferentiated duct-spaces (below), and adult pancreatic acini (right). The lobules are separated by smooth-muscle bundles which are an intrinsic part of the tumour.

occurs it does so not in the aberrant tissue but in the adjacent intestinal mucosa.

The clinical features of peptic ulcer are fairly characteristic. Eighty per cent of cases occur in males and the chief incidence is in infancy and childhood: over 50 per cent occur during the first decade and nearly 75 per cent before the age of 16 years (Matt and Timpone, 1940). Abdominal pain is not a constant feature; the cardinal symptom is intestinal haemorrhage, often copious and usually intermittent, occurring at intervals of weeks or months. This is a most important diagnostic sign, occurring as it does in young subjects without obvious cause. Treatment is essentially surgical and laparotomy should be undertaken as early as possible, in view of the grave possibilities involved.

Intestinal haemorrhage

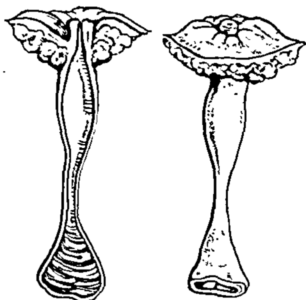


FIG. 259.—"Sentinel" umbilical polyp associated with a patent vitelline remnant continuous with a Meckel's diverticulum: a potential cause of acute obstruction.

At the umbilicus superficial heterotopia may be seen in the form of sessile or pedunculated polyps of reddish colour, clothed by mucous membrane of intestinal or, more rarely, of gastric type. These are of little clinical importance *per se*, apart from the constant friction and secretory discharge which they occasion, but sometimes they may afford a diagnostic clue to associated intra-abdominal malformations, such as an anchored Meckel's diverticulum or a fibrous vitelline remnant, causing acute obstruction (Taylor, 1931) (Fig. 259).

Clue to associated malformations

(*b*) *Deep*

Abnormal epithelial differentiation beneath the muscularis mucosae may give rise to a variety of heterotopic structures ranging from small intramural glands or cysts to tumours of considerable size. The majority of these are composed of pancreatic tissue: others may exhibit a wide variety of types of cell, all of which, however, are normal constituents of some portion of the intestinal tract.

(i) *Accessory pancreas.*—Solid masses of aberrant pancreatic tissue are not uncommonly found in the stomach, duodenum and jejunum, presenting as firm yellowish tumours or plaques incorporated in the submucous and muscular coats. Lower down they are rare except in relation to Meckel's diverticulum. Microscopically their differentiation is complete even to the presence of the highly specialized islets of Langerhans. Almost always they are

(3) Connective tissue heterotopia

Heterotopia is by no means confined to the epithelial tissues of the body, and examples may be encountered, though rarely, in tissues of mesenchymal origin. These are almost always of acquired type, occurring during the reparative activities following local trauma or inflammatory disturbance. Here also the process is one of metaplasia; the young proliferating cells of regenerative granulation tissue re-acquire developmental potencies comparable with those of primitive mesenchyme, so that abnormal differentiation may result in the formation of a variety of adult structures which are foreign to the part concerned. A striking instance of special interest to the surgeon is the development in scar tissue of true bone, sometimes accompanied by cartilage and containing well-formed bone-marrow with all its specialized elements. Similar bony heterotopias may be seen in myositis ossificans, in old inflammatory lesions and long-standing haematomas, and in the walls of senile arteries. Of these heterotopic tissues, Willis (1948) points out that: "None . . . can be immigrants; they must all arise by divergent differentiation from the local fibroblastic and vasoformative elements of the reparative tissue."

REFERENCES

Lewis, F., and Thyng, F. W. (1908). *Amer. J. Anat.*, 7, 505.
Matt, J. G., and Timpone, P. J. (1940). *Amer. J. Surg.*, 47, 612.
Nicholson, G. W. (1922). *Guy's Hosp. Rep.*, 72, 75.
Stewart, M. J., and Taylor, A. L. (1925). *J. Path. Bact.*, 28, 195.
Taylor, A. L. (1927). *J. Path. Bact.*, 30, 415.
— (1931). *Bristol med.-chir. J.*, 48, 113.
Willis, R. A. (1948). *Pathology of Tumours*, p. 642. London; Butterworth.

[References to other titles are given under Heterotopia in the Index Volume.]

Microscopically, groups of poorly differentiated duct spaces and cystic acini intermingle with islets of adult pancreatic tissue and secretory glands of Brunner type (Fig. 261). Even squamous epithelium has been observed, providing, incidentally, an irrefutable proof of the dysontogenetic nature of these heterotopias (Taylor, 1927).

Proof of dysontogenetic nature

The clinical features of adenomyoma are not diagnostic, but resemble in some respects those of gastro-duodenal ulceration. The symptoms range from intermittent epigastric discomfort and nausea to severe pain of the "hunger" type, which is relieved on taking food (Stewart and Taylor, 1925). As would be expected from a consideration of the morbid anatomy of the condition, haematemesis and melaena do not occur, nor are the usual diagnostic procedures likely to provide more than negative evidence. Adenomyoma is essentially a simple tumour and malignant change is extremely rare, so that once identified it is satisfactorily treated by local excision rather than by extensive gastric resection.

Gastric resection undesirable

3. ACQUIRED HETEROTOPIA

Acquired heterotopia is the result of chronic local inflammation when accompanied by tissue destruction, and like the congenital variety may be superficial or deep.

(1) Superficial

Influence of metaplasia

Superficial heterotopia depends on metaplasia, a process of abnormal re-differentiation of the germinal cells in the injured part. In long-standing inflammatory lesions there is a demand for continued rapid division of these cells which thereby appear to regain some of their embryonic potentialities; differentiation may then pursue an aberrant course giving rise to adult cells of a type not normally found at that particular site. Thus we may explain the appearance of intestinal epithelium in the regenerating mucosa of chronic gastric ulcer and of squamous epithelium in bronchiectatic cavities or calculous renal pelves. In this connexion it may be noted that metaplastic epithelium is in general less specialized than that which it replaces. Squamous epithelium is the least specialized of all, and appears incapable of abnormal differentiation; for this reason metaplasia is never seen in chronic lesions of the skin.

(2) Deep

Deep heterotopia of acquired origin is rarely found in the skin except in the form of implantation dermoids following local injury. On microscopy, examples of the condition are commonly seen along the course of the alimentary tract, in the walls of chronic ulcers of the stomach and intestine, and in their resulting scars. They result from the rapid growth of regenerating epithelium which may be segregated in the submucosa during the healing process. These glandular islets may be distorted or cystic, but their component cells possess regular adult structure and show no sign of atypical or malignant growth. In fact, there is no evidence that acquired heterotopias, whether superficial or deep, undergo malignant transformation. Malignancy and heterotopia may occur together in chronic ulcerative lesions, but the two conditions are quite independent.

Malignancy and heterotopia independent conditions

followed World War I. The publicity given to these cases was responsible for outbreaks of apparently hysterical hiccup; the same mass phenomena sometimes follow newspaper accounts of intractable hiccup and "crops" of hiccups occur having origin in hysteria as in the original outbreak.

Irritation of the afferent fibres of the phrenic nerve is said to cause hiccup, and the conditions which produce the symptom in this way include mediastinal tumours, mediastinitis, pericarditis with effusion, subdiaphragmatic abscess and diaphragmatic pleurisy. Whether the phrenic nerve is implicated or not, these are rare causes of hiccup.

Hiccup is regarded as a symptom of ill omen when it occurs in typhoid fever, dysentery or cholera, all intestinal diseases which may be associated with gut distension and also with peritonitis, but here also the effect may be central since it occurs in the most toxic cases.

Post-operative symptom

It is a troublesome post-operative symptom especially after abdominal operations. If it comes on immediately after such an operation it may not be of much importance, but the later it comes on the more likely it is to be due to gastric distension, ileus or peritonitis. It frequently follows operations on the bladder and prostate. Sometimes the cause appears to be uraemia, in which condition hiccup is certainly found, but it also occurs in patients with normal renal function, and possibly ileus is the precipitating factor in these cases.

3. PROGNOSIS

The prognosis is as variable as are the causes. Although ordinarily of little importance it is a serious symptom in the late stages of any severe illness or a few days after an abdominal operation in cases in which there are other signs of deterioration—serious chiefly because of what it denotes rather than because of its own effects. It may be very exhausting, interfere with nutrition and sleep and prove fatal in debilitated patients.

4. GENERAL TREATMENT

Counter-irritation

Suggested remedies are legion and depend for their effect on the various responses to counter-irritation, sedation, psychological suggestion and the relief of distension.

Hippocrates observed the effect of some strong overriding stimulus and stated that: "Sneezing coming on removes the hiccup." Snuff, pepper, smelling salts and amyl nitrite have all been used for this or kindred purposes.

Counter-irritation by means of cold douches, ethyl chloride sprayed on the epigastrium, faradic currents, pressure on the eyeball, tongue traction or pressure over the carotids or the phrenic nerve itself, has been claimed to be effective.

Carminatives

Carminatives are sometimes effective and tincture of iodine and oil of cajuput are traditional. Brandy and whisky are used for the same purpose.

Another line of treatment is by the use of sedatives; chloral hydrate or paraldehyde per rectum, morphine, Dilaudid and the barbiturates all have their advocates. Benzyl benzoate, half a drachm of 20 per cent alcoholic solution in water or milk, is well worth trying. Pethidine by mouth or by injection is the most generally effective drug.

Distension may be relieved by means of gastric lavage or by the passage of

HICCUP

By E. R. BOLAND, M.D., F.R.C.P.
Physician, Guy's Hospital, London

1. DEFINITION

184.] Hiccup is an onomatopoeic word which imitates the sound produced by the involuntary inspiratory contraction of the diaphragm checked by the reflex closure of the glottis.

2. AETIOLOGY

Reflex origin

This complex symptom is reflex in origin, the efferent path being the phrenic nerve (cervical nerves 3, 4 and 5) for the diaphragm, and the laryngeal branches of the vagus for the glottis. The afferent paths are not accurately known but presumably the vagus innervation of the stomach and intestines is involved. It is probable that there is also an afferent path up the phrenic nerve. The central portion of the reflex has been ascribed to the middle part of the cervical cord but it is probably in the brain stem or even above it.

Normal causes

Hiccup can be produced in normal people by too rapid gobbling of food or by drinking too fast—for example, directly out of a bottle. Presumably the air swallowed in this way produces the distension of the stomach which is the stimulus in these cases. Greedy infants at the breast or the bottle often hiccup until they are held upright and the air is encouraged to escape. Irritation of the stomach by means of hot fluids, spices, curries and so forth produces the symptom in some people although aerophagy may also be the explanation here. Alcohol is a traditional cause of hiccup although it is not so common a cause as the music-hall comedians would suggest; probably it is more frequently caused by smoking a foul pipe or a strong cigar. In both cases the hiccup might be due either to irritation of the stomach or to a central toxic effect since other toxic symptoms are commonly associated.

These may be termed the normal causes of hiccup because they are universal; they are of little importance because the hiccup so produced is more embarrassing than important, is usually self-limited, and yields easily to some home remedy.

Central and peripheral causes

There are, however, more sinister causes of hiccup. They are often divided into central and peripheral causes but, while some are certainly central in origin and some certainly peripheral, there are many intermediate ones which it is impossible to assign to either group.

Hiccup due to encephalitis lethargica, meningitis, head injury, tumour or cerebral haemorrhage is certainly central. Many cases were seen in Great Britain and other countries at the time of the pandemic of encephalitis which

followed World War I. The publicity given to these cases was responsible for outbreaks of apparently hysterical hiccup; the same mass phenomena sometimes follow newspaper accounts of intractable hiccup and "crops" of hiccups occur having origin in hysteria as in the original outbreak.

Irritation of the afferent fibres of the phrenic nerve is said to cause hiccup, and the conditions which produce the symptom in this way include mediastinal tumours, mediastinitis, pericarditis with effusion, subdiaphragmatic abscess and diaphragmatic pleurisy. Whether the phrenic nerve is implicated or not, these are rare causes of hiccup.

Hiccup is regarded as a symptom of ill omen when it occurs in typhoid fever, dysentery or cholera, all intestinal diseases which may be associated with gut distension and also with peritonitis, but here also the effect may be central since it occurs in the most toxic cases.

Post-operative symptom

It is a troublesome post-operative symptom especially after abdominal operations. If it comes on immediately after such an operation it may not be of much importance, but the later it comes on the more likely it is to be due to gastric distension, ileus or peritonitis. It frequently follows operations on the bladder and prostate. Sometimes the cause appears to be uraemia, in which condition hiccup is certainly found, but it also occurs in patients with normal renal function, and possibly ileus is the precipitating factor in these cases.

3. PROGNOSIS

The prognosis is as variable as are the causes. Although ordinarily of little importance it is a serious symptom in the late stages of any severe illness or a few days after an abdominal operation in cases in which there are other signs of deterioration—serious chiefly because of what it denotes rather than because of its own effects. It may be very exhausting, interfere with nutrition and sleep and prove fatal in debilitated patients.

4. GENERAL TREATMENT

Counter-irritation

Suggested remedies are legion and depend for their effect on the various responses to counter-irritation, sedation, psychological suggestion and the relief of distension.

Hippocrates observed the effect of some strong overriding stimulus and stated that: "Sneezing coming on removes the hiccup." Snuff, pepper, smelling salts and amyl nitrite have all been used for this or kindred purposes.

Counter-irritation by means of cold douches, ethyl chloride sprayed on the epigastrium, faradic currents, pressure on the eyeball, tongue traction or pressure over the carotids or the phrenic nerve itself, has been claimed to be effective.

Carminatives

Carminatives are sometimes effective and tincture of iodine and oil of cajuput are traditional. Brandy and whisky are used for the same purpose.

Another line of treatment is by the use of sedatives; chloral hydrate or paraldehyde per rectum, morphine, Dilaudid and the barbiturates all have their advocates. Benzyl benzoate, half a drachm of 20 per cent alcoholic solution in water or milk, is well worth trying. Pethidine by mouth or by injection is the most generally effective drug.

Distension may be relieved by means of gastric lavage or by the passage of

a duodenal tube with continuous suction. The administration of an enema and the passage of a flatus tube are advisable and acetylcholine intramuscularly or Doryl by mouth is given with the object of relieving ileus.

Inhalation of carbon dioxide

The inhalation of carbon dioxide is often effective. This treatment is derived from the old trick of breathing in and out into a closed paper bag in order to cure hiccup. The inhalation should be by means of a B.L.B. mask using oxygen and 5–7 per cent carbon dioxide. Phrenic avulsion either unilateral or bilateral has been carried out for intractable hiccup but can rarely be justified.

The number of remedies, of which a small selection has been given, suggests that the treatments are equally good or equally bad.

5. TREATMENT OF POST-OPERATIVE HICCUP

Isolation of patient

Patients with intractable hiccup are inclined to become emotional and are affected by the agitation, irritation or sympathy of other patients or of their attendants. If possible, they should be isolated in order to minimize this effect. They should be propped up in bed with the trunk bent forward if their condition allows of this. Pethidine (50 milligrams) should be given by mouth or by injection and repeated if necessary, and oxygen and carbon dioxide should be given with a B.L.B. mask. If this treatment is ineffective, gastric lavage should be started followed if necessary by continuous suction drainage. Feeding may prove to be difficult but, when appropriate, feeds can be administered through the tube if the patient is unable to swallow, or total intravenous feeding can be undertaken. It is assumed here that in treating the symptom the treatment of the disease is not forgotten.

BIBLIOGRAPHY

Bailey, H. (1943). *Practitioner*, **150**, 173.
Bellingham-Smith, E. (1938). *Practitioner*, **140**, 166.
Campbell, M. F. (1940). *Amer. J. Surg.*, **48**, 449.
Douthwaite, A. H. (1938). *Guy's Hosp. Gaz.*, **52**, 447.
East, C. F. T. (1926). *Lancet*, **2**, 140.
Mayo, C. W. (1932). *Surg. Gynec. Obstet.*, **55**, 700.
Nesbitt, S. (1934). *Yale J. Biol. Med.*, **6**, 9.
Noble, E. C. (1934). *Canad. med. Ass. J.*, **31**, 38.
Pendleton, W. R. (1927). *Amer. J. Physiol.*, **81**, 707.
Rosenow, E. C. (1942). *J. Lab. clin. Med.*, **28**, 277.
Wagner, I. F. (1938). *J. gen. Psychol.*, **52**, 233.

[References to other titles are given under Hiccup in the Index Volume. The subject of Hiccup is also dealt with under the heading of Diaphragm Diseases in the *British Encyclopaedia of Medical Practice* (1937), Vol. 3, p. 673.]

NOTE.—Upon completion of the whole work an exhaustive analytical Index will be published in a separate volume. Each individual title in this volume has been separately indexed and its subject-matter subdivided beneath that main title; additional references and cross-references beyond this, under the name of any particular subject, have been included. No attempt has been made to include references to subject-matter appearing in this volume which is dealt with fully in future volumes, although in one or two instances it has been possible to give the volume in which this subject is appearing.

THE PUBLISHERS

INDEX TO VOLUME 4

A

B

C

D

E

F

G

H

K

L

M

N

I

J

R

O

P

R

S

T